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Task Order 1
Remedial Investigation/Feasibility Study

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Task Order 1

FEASIBILITY STUDY (OUTDOOR) FOR BASE CLOSURE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
ARMY MATERIALS TECHNOLOGY LABORATORY
WATERTOWN, MASSACHUSETTS

Contract No. DAAA15-90-D-0009

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This report is one of three reports that address technologies and remedial action alternatives that may be applied to the U.S. Army Materials Technology Laboratory (MTL) in Watertown, Massachusetts. This report discusses on-site outdoor areas (soil and groundwater). The second report discusses indoor building surfaces and the third report discusses surface water and sediments. The evaluation in this report was performed in accordance with the National Contingency Plan (40 CFR 300) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This report uses the results from the site Remedial Investigation and risk assessments for human health and ecological receptors. From this information, site cleanup goals and areas to be remediated were established. A variety of remedial technologies were identified and evaluated. Those applicable technologies were assembled into site remedial action alternatives. These alternatives were then evaluated in detail using CERCLA criteria. These criteria include overall protection of human health and the environment, compliance with applicable or relevant and appropriate requirements (ARARs), short-term effectiveness, long-term effectiveness and permanence, reduction of toxicity, mobility, and volume of contaminants through treatment, implementability, and cost.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ADL	Arthur D. Little, Inc.
AEC	Army Environmental Center
AMMRC	Army Materials and Mechanics Research Center
ANL	Argonne National Laboratory
APEG	alkaline polyethylene glycol
ARAR	Applicable or Relevant and Appropriate Requirement
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc.
BAT	best available technology
BCT	best conventional pollutant control technology
BDAT	best demonstrated available technology
bgs	below ground surface
BHC	benzenehexachloride
BNA	base/neutral/acid extractable organic compounds
BRAC	Base Realignment and Closure
Btu	British thermal unit
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
DDE	1,1-bis(4-chlorophenyl)-2-chloroethane
DMSO	dimethyl sulfoxide

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

DOD	Department of Defense
DOT	Department of Transportation
DPH	Department of Public Health
dpm	disintegrations per minute
DRE	destruction and removal efficiency
DU	depleted uranium
EM/SVE	electromagnetic heating with soil vapor extraction
EP	extraction procedure
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FDP	Facility Decommissioning Plan
FS	feasibility study
FWCA	Fish and Wildlife Coordination Act
GAC	Granular activated carbon
gpm	Gallons per minute
GPR	ground-penetrating radar
GSA	General Services Administration
GZA	Goldberg Zoino Associates, Inc.
HCl	hydrogen chloride
HDPE	high-density polyethylene
HEPA	high-efficiency particulate air
HI	Hazard Index

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LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

IRDMIS	Installation Restoration Data Management Information System
IRP	Installation Restoration Program
ISV	In situ volatilization
KPEG	potassium polyethylene Glycol
LDPE	low-density polyethylene
LDR	Land Disposal Restriction
MADEP	Massachusetts Department of Environmental Protection
MAGW	Massachusetts groundwater
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCP	Massachusetts Contingency Plan
MDC	Metropolitan District Commission
MDPE	medium-density polyethylene
mrem	millirems
MSL	mean sea level
MTL	Materials Technology Laboratory
MWRA	Massachusetts Water Resources Authority
m-xylene	1,3-dimethylbenzene
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NDE	nondestructive examination

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NJDEPE	New Jersey Department of Environmental Protection and Energy
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NSPS	New Source Performance Standards
O&M	operating and maintenance
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PA/SI	preliminary assessment/site inspection
PCB	polychlorinated biphenyl
ppb	parts per billion
ppm	parts per million
PCE	tetrachloroethylene
PEL	permissible exposure level
PF	potency factor
POHC	principal organic hazardous constituent
POTW	publicly owned treatment works
psi	pounds per square inch
PTN	Property Transfer Notification

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

PVC	polyvinyl chloride
QA	quality assurance
RA	risk assessment
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
REDOX	reduction/oxidation
REL	recommended exposure level
RfD	reference dose
RI	remedial investigation
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SOC	Statement of Condition
SOW	Statement of Work
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TBC	to be considered
TC	toxicity characteristic
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
THAMA	Toxic and Hazardous Materials Agency

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

TLV	threshold limit value
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSS	total suspended solids
TWA	time-weighted average
USACE	U.S. Army Corps of Engineers
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound
WESTON	Roy F. Weston, Inc.
WHO	World Health Organization

EXECUTIVE SUMMARY

This Feasibility Study (FS) is one of three reports that address technologies and remedial action alternatives that may be applied to mitigate potential risks to human health and the environment posed by contaminants at the U.S. Army Materials Technology Laboratory (MTL) in Watertown, Massachusetts. This report discusses the outdoor areas of the site, where recent studies have indicated that the soils would require remediation. A second report discusses indoor areas of buildings. A third report (yet to be completed) will address the Charles River surface water and sediments. This FS was prepared by Roy F. Weston, Inc. (WESTON®) for the U.S. Army Environmental Center (AEC) as part of the Army's Base Realignment and Closure Program (Contract DAAA15-90-D-0009, Task Order 1 and its associated modifications).

The FS identifies and screens a variety of remedial technologies that may be feasible for addressing the potential risks to the public and the environment posed by the contamination at the site. From these technologies, several remedial alternatives were developed, screened, and evaluated in detail. On May 30, 1994, the installation was added to the National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund Program. As a result, there has been a transition of regulatory authority from the Massachusetts Department of Environmental Protection to the U.S. Environmental Protection Agency (EPA) Region I. This investigation is required to follow the requirements of the National Contingency Plan (NCP). This report is intended to meet the requirements of the NCP and also meets many of the substantive requirements of the Massachusetts Contingency Plan (MCP).

The reuse of any parcel of land must be determined to define the required level of remediation. Residential reuse would require the greatest extent of remediation, while industrial reuse would result in a lower level of remedial action. Soil volumes for cleanup were estimated for each of three possible site reuse scenarios based on commercial and residential reuse for the four zones at MTL as defined by the Watertown Arsenal Reuse Committee. The site reuse scenarios are as follows:

Scenario 1 — Commercial reuse for Zones 1, 2, and 3, public access for Zone 4 and River Park.

Scenario 2 — Residential reuse for Zones 1, 2, and 3, public access for Zone 4 and River Park.

Scenario 3 — Commercial reuse for Zones 1 and 2, residential reuse for Zone 3, and public access for Zone 4 and River Park.

Findings of the Phase 2 Remedial Investigation (Outdoor Areas)

An extensive sampling program was conducted for site soils, site groundwater, surface water (Charles River), sediments, storm sewers, and sanitary sewers. Samples were analyzed for volatile and semivolatile organics, pesticides, inorganic parameters, metals, and radiological parameters. No assessment of results from the Charles River surface water and sediments is provided in this FS, as it is not part of this scope (they are being addressed in a separate report). Sampling results from soil, groundwater, and sewers indicated the presence of low to moderate levels of contamination in each of these media.

An assessment was made for site groundwater as to whether the detected contamination had a significant risk to human health or the environment. The groundwater is not a current or future source of drinking water (MADEP has classified the aquifer as GW-3) and groundwater is not used for industrial purposes. Therefore, a human health assessment was not required. Impacts of groundwater on the Charles River have been found to be negligible. These findings indicate that groundwater remedial action is not necessary at the MTL facility.

Risk Assessment

A risk assessment for potential future exposure to contamination was conducted on the sampling results from soil and the on-site sewers. For contaminated soils, there are no specific federal or state cleanup standards or levels; therefore, in determining areas requiring remediation and appropriate cleanup levels, the risk assessment was used to determine these levels based on the action levels for human exposure to carcinogens and human and ecological exposure to noncarcinogenic effects. For human health, the EPA target carcinogenic risk range is 1E-04 to 1E-06 pursuant to the NCP; the MCP action level for carcinogenic risk is 1E-05 for total site risk. The human health action level for noncarcinogenic effects for both the NCP and MCP is a hazard index greater than 1. A separate risk assessment was performed to determine ecological risks. For ecological risk, an action level of a hazard index greater than 10 was used, as agreed to by EPA. The risk assessment indicated that risks exceeding action levels were present for certain soils. Therefore, remedial action is required for site soils.

A separate risk assessment was conducted for on-site sewers. This assessment evaluated the future sewer worker. The results of this assessment showed an insignificant risk to the worker. Hence, no remedial action is required for site sewers.

Development of Soil Cleanup Goals

From the results of the human health soil risk assessment, risk-based soil cleanup goals were determined for each contaminant of concern that would achieve the regulatory risk goal. The results of this showed that, for the most part, the value of the risk-based soil cleanup goals were substantially below site background concentrations. Therefore, background levels became the site soil cleanup goals. A statistical evaluation of

background data was used to develop the numerical value to be used as the cleanup goal for each contaminant.

In addition to this methodology, ecological risk-based goals were also developed for areas of ecological concern (Zone 4 and River Park). In these areas, for contaminants where human health-based (background) and ecological-based cleanup goals were determined, the more conservative cleanup goal was used for that area.

Remedial Action Objectives

The remedial action objective for outdoor areas at MTL is as follows:

- Mitigate the risks to human health and the environment posed by direct contact with risk-based soils.

Using the derived soil cleanup goals, site areas were delineated where soil exceeds the specific cleanup goals. Because of the three possible site reuse scenarios, the contaminants of concern vary for the different scenarios. Therefore, site soil areas requiring remedial action were delineated for each of the three reuse scenarios.

Identification and Screening of Remedial Action Technologies

Based on the RI results and remedial action objectives, several general response actions and remedial action technologies and process options were identified as potentially applicable for soil remediation in outdoor areas at MTL. These technologies and process options were then screened according to the following criteria:

- Site characteristics
- Contaminant characteristics
- Technology limitations
- Technology implementation

These criteria were used to determine if a technology or process option is to be retained or eliminated from further consideration. During this evaluation, technologies or process options can be eliminated if they cannot be feasibly implemented, do not apply to the site-specific contaminants, or cannot treat or remove the site contaminant to the desired cleanup goals. The technologies that were retained after this initial screening are the following:

- Migration pathway monitoring
- Access restrictions
- Capping
- Runon/runoff controls
- Excavation
- Incineration
- Low-temperature thermal treatment
- Soil washing

- Solvent extraction
- Chemical oxidation
- Chemical dechlorination
- Solidification/stabilization
- Off-site landfill
- On-site disposal

Technology process options that were eliminated during this screening step included:

- Soil flushing
- In situ vitrification
- Soil vapor extraction (SVE)
- Electromagnetic heating with SVE
- In situ stabilization
- Macroencapsulation
- Landfarming/composting
- Bioreactors
- Chemical dechlorination
- On-site landfill

Development and Screening of Remedial Action Alternatives

Six alternatives were developed for soil based upon site-specific conditions and the technology process options retained from the screening process. These alternatives mitigate the potential public health risks posed by the site contaminants to varying degrees. According to NCP guidance, some alternatives are developed to treat or remove contaminants to levels that will meet acceptable public risk. Other alternatives are developed that will not treat or remove contaminants to meet acceptable risk levels, but are used for a baseline comparison with the other alternatives. The remedial action alternatives for the MTL outdoor areas are:

- S1 No Action.

- S2 Institutional Controls.

- S3 Capping of Soils.

- S4 Soil Excavation and Thermal Treatment.

  - Option A — On-Site Incineration.
  - Option B — Off-Site Incineration.
  - Option C — On-Site Low-Temperature Thermal Desorption.

- S5 Soil Excavation and On-Site Chemical Treatment.

  - Option A — Chemical Oxidation.
  - Option B — Solvent Extraction.

- S6 Soil Excavation and Off-Site Disposal or Reuse.

As described above, Alternatives S1, S2, and S3 will not treat or remove contaminants. Alternatives S1 and S2 do not mitigate risk except through institutional controls (Alternative S2 only), and S3 mitigates risk by prevention of direct contact with contaminated soil. Alternatives S4 through S6 are expected to treat or remove contaminants to levels that will meet acceptable goals.

These remedial alternatives were then screened on the basis of their effectiveness, implementability, and cost. During this screening, all alternative and alternative options were retained.

The six soil alternatives with the retained options were then subjected to the detailed analysis summarized below.

Detailed Analysis of Remedial Action Alternatives

Each of the soil alternatives was analyzed by the following criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume of contaminants
- Short-term effectiveness
- Implementability
- Cost

Each alternative was summarized and compared on the basis of cost and noncost criteria. Table ES-1 summarizes the primary components for each alternative. Implementation costs were estimated for each remedial alternative. To equally compare the costs of each alternative, a present-value analysis was performed on the implementation costs of each alternative. In the analysis, the future costs of the alternatives are converted to 1995 dollars. Costs for each alternative (except Alternatives S1 and S2) were determined for each site reuse scenario.

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Table ES-1

Summary of Soil Remedial Action Alternatives

Alternative	Alternative Name	Description
S1	No Action	No remedial or risk reduction actions taken.
S2	Institutional Controls	No remedial actions are undertaken; however, measures are taken to reduce the potential risk to human health and the environment. These measures include upgraded site security, restrictions on future site development, and preventing soil use for agricultural purposes.
S3	Capping of Soils	An asphalt cap is placed over contaminated soils to prevent contact with the soils. Runon/runoff controls are used during installation. Long-term maintenance of the cap is provided.
S4	Soil Excavation and Thermal Treatment • Option A — On-Site Incineration • Option B — Off-Site Incineration • Option C — On-Site Low-Temperature Thermal Desorption	Contaminated soils are excavated and incinerated by a rotary kiln that is either a mobile on-site unit or an off-site unit or are treated on-site by thermal desorption. For on-site incineration or thermal desorption, treatment for off-gases is included; treated soils are backfilled on-site. For off-site incineration, contaminated soils are transported to the incinerator location; excavations are backfilled with clean soil.
S5	Soil Excavation and On-Site Chemical Treatment • Option A — Chemical Oxidation • Option B — Solvent Extraction	Contaminated soils are excavated and treated on-site by a soil chemical oxidation or solvent extraction treatment system to remove necessary contaminants. Treated soil is backfilled on-site. Waste solvent solutions (solvent extraction only) are treated or disposed as necessary.
S6	Soil Excavation and Off-Site Disposal or Reuse.	Contaminated soils are excavated and transported to an off-site waste landfill. Excavations are backfilled with clean soil.

SECTION 1

INTRODUCTION

1.1 PROJECT SCOPE

Roy F. Weston, Inc. (WESTON®) was contracted by the U.S. Army Environmental Center (AEC) as part of the Army's Base Realignment and Closure (BRAC) Program (Contract DAAA15-90-D-0009, Task Order 1 and its associated modifications) to conduct two remedial investigations (RIs) and a feasibility study (FS) at the Army Materials Technology Laboratory (MTL) in Watertown, Massachusetts. AEC, formerly known as the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), is responsible for the BRAC environmental investigation program at this facility. The objective of this program is to identify contamination resulting from past operations on Army properties throughout the United States.

Under Task Order 1, WESTON has been contracted to:

- Develop a Phase 1 RI report using existing data collected by EG&G and Arthur D. Little, Inc. (ADL) between 1988 and 1990.
- Conduct a Phase 2 RI whose field effort supplements that of Phase 1 in providing a more complete database.
- Conduct a study of potential cross-contaminated areas at MTL for use in screening remedial alternatives where mixed wastes may be involved.
- Conduct a detailed radiological survey of the facility buildings and grounds and use the data collected in a Facility Decommissioning Plan (FDP).
- Conduct an FS.
- Conduct post-FS activities, such as preparation of a proposed plan, a responsiveness summary, and a regulatory record of decision (ROD).

Sampling activities for the Phase 2 RI were conducted between September 1991 and February 1992.

The environmental investigations/evaluations, up to and including the previous versions of this FS, have been conducted following the requirements of the Massachusetts Contingency Plan (MCP). On May 30, 1994, the installation was added to the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund Program. As a result, there has been a transition of regulatory authority from the

Massachusetts Department of Environmental Protection (MADEP) to the U.S. Environmental Protection Agency (EPA) Region I. Therefore, this FS and all future investigations/evaluations are required to follow the requirements of the National Contingency Plan (NCP). This FS report is intended to meet the requirements of the NCP. This report also meets many of the substantive requirements of the MCP as specified in 310 CMR 40.0850, which addresses Phase III Comprehensive Response Actions under the MCP.

Because of the complexity of this site and varying regulatory authority, the site has been divided into three separate Operable Units (OUs). The units are: 1) outdoor site areas (i.e., soil, groundwater, and sewers); 2) building interiors; and 3) Charles River surface water and sediments. Although MTL has been added to the NPL, EPA has assumed regulatory authority over the outdoor portion of the facility only. The remediation of building interiors, as well as the remediation of petroleum, oil, and lubricant at MTL, remains under the auspices of MADEP. This report contains the FS for the first operable unit and discusses environmental media at MTL other than building interiors, containers (e.g., tanks, sumps, etc.), and the Charles River surface water and sediments. This FS is referred to as the Outdoor FS. The document addressing building interiors and containers is referred to as the Remedial Action Plan for Indoor Surfaces (RAP) and is presented in draft final form in a separate report. Additionally, the Charles River surface water and sediments are being addressed separately by the Army under the purview of CERCLA with EPA oversight. A separate report on the Charles River surface water and sediments operable unit will be prepared at the conclusion of additional work on this unit. The OUs into which the installation has been divided, and the most recent reports that discuss these OUs are listed below:

- Building Interior Surfaces — <u>Remedial Action Plan for Indoor Surfaces at AMTL</u> (WESTON, June 1995).

- Charles River Surface Water and Sediments and MTL Storm Sewer System — <u>Charles River Follow-Up Sampling Program Draft Final Conceptual Plan</u> (WESTON, January 1995).

- Charles River Surface Water and Sediments — <u>Draft Charles River Phase 2 Supplemental River Investigation — Technical Work Plans</u> (PLEXUS, July 1995).

- Outdoor Portions of the Installation, Excluding the Charles River Operable Unit — This Document.

As part of the Phase 2 RI, a Baseline Human Health Risk Assessment/Environmental Evaluation was performed by Life Systems, Inc. of Cleveland, Ohio. The results of the Human Health Risk Assessment, with the exception of those risks caused by exposures to indoor surfaces, are presented in Section 6 of the Phase 2 RI report (WESTON, May 1994). A human health evaluation based on risks caused by chemical exposures from building interiors is presented in a separate report entitled "Human Health Evaluation of Exposures to Indoor Building Surfaces" (Life Systems, January 1995). The results

of the environmental evaluation are presented in a report entitled "Baseline Risk Assessment-Environmental Evaluation" (Life Systems, December 1993). Because this report determined that terrestrial populations and communities in this area of MTL were of limited ecological significance, the only endpoints considered in the baseline ecological evaluation were the aquatic resources of the Charles River. Following the additions of the installation to the NPL, and subsequent transfer of regulatory authority to EPA, it was determined that terrestrial exposure endpoints could be significant, and a separate terrestrial ecological assessment was conducted. The results of this assessment are presented in a report entitled "Terrestrial Ecological Risk Assessment" (WESTON, June 1995).

Post-RI investigations of two sites within the installation are presented in a report entitled "Final Engineering Report: Predesign Investigation- Buildings 60/227 and Well C-2 Areas" (ABB-ES, December 1994). This report has been issued since the completion of the Draft Final Outdoor FS (WESTON, February 1994). This report discusses post-RI investigations performed to address additional concerns that surfaced during the performance of Phase 2 field activities. Results and recommendations from this report are discussed briefly in this section. However, it should be noted that the investigations described in the ABB-ES report were performed under the requirements of the MCP (310 CMR 40.0000). Post-RI studies at the Building 60/227 and well C-2 sites fall only under the regulatory authority of MADEP as specified in the MCP. This shift in regulatory primacy for these two sites at the installation is the result of suspected petroleum releases discovered during Phase 2 field activities. Petroleum is the only contaminant of concern at these sites; CERCLA has no specific provisions governing petroleum releases to soil or groundwater. Remedial actions at these two sites are to be conducted separately from actions conducted under the NCP at the remainder of the sites on the installation. Further discussions of these areas are presented in Subsections 1.2.2.5 and 1.2.4.3.2.

1.2 BACKGROUND INFORMATION

1.2.1 INSTALLATION HISTORY

The MTL property is located on 36.5 acres of land in Watertown, Massachusetts, on the north bank of the Charles River approximately 5 miles west of downtown Boston (see Figure 1-1 located in Appendix A). The installation is bounded on the north by Arsenal Street, on the south by North Beacon Street, on the east by Talcott Avenue, and on the west by the Veterans of Foreign Wars, USA, Burnham Manning Post No. 105, and private property. An additional 11 acres of federal land south of the site and abutting the Charles River are controlled by the Commonwealth of Massachusetts and consist of a public roadway (North Beacon Street), a public park, and a yacht club. This 11-acre parcel is considered part of the NPL site and will vest permanently and unconditionally to the Commonwealth upon disposal of MTL (USACE-NED, 1991). Figure 1-2 provides a topographic map of the Watertown area, including the MTL site.

The facility was established as the Watertown Arsenal in 1816 by President James Madison and was originally used for the storage, cleaning, repair, and issue of small

arms and ordnance supplies. During the 1800s, this mission was expanded to include ammunition and pyrotechnics production; materials testing and experimentation with paint, lubricants, and cartridges; and manufacture of breech-loading steel guns and cartridges for field and siege guns. The mission, staff, and facilities continued to expand until after World War II, at which time the facility encompassed 131 acres, including 53 buildings and structures, and employed approximately 10,000 people. Arms manufacturing continued at the facility until an operational phasedown was initiated in 1967. In 1960, the Army's first materials research nuclear reactor was completed at MTL and was used actively in molecular and atomic structure research activities until 1970 when it was deactivated.

At the time of phasedown, much of the Watertown Arsenal property was transferred to the General Services Administration (GSA), and in 1968, approximately 55 acres were sold to the town of Watertown and subsequently used for the construction of apartment buildings, the Arsenal Mall, and a public park and playground. Of the 47.5 acres retained by the Army, 36.5 acres became the Army Materials and Mechanics Research Center (AMMRC), which was designated an historical landmark by the American Society of Metals in 1983. In 1991, the 36.5-acre parcel was designated a national historical district.

In 1985, the AMMRC became the Materials Technology Laboratory (MTL), which, at the time of Phase 2 field activities, employed approximately 500 people. In 1993, the MTL became the Army Research Laboratory (ARL). However, since all previous documents published under this contract refer to the installation as MTL, that convention will be retained in this FS. MTL currently employs an estimated 24 people, and contains 15 major buildings and 15 associated structures. The former mission of MTL was materials development, structural integrity testing, solid mechanics, lightweight armor development, and manufacturing testing technology. All work involving the machining and testing of materials containing depleted uranium (DU) at the installation ceased as of April 1991.

In October 1988, Congress passed the Defense Authorization Amendments and Base Realignment and Closure Act (Public Law 100-526). In December 1988, the Secretary of Defense's ad hoc Commission on Base Realignment and Closure issued its final report that included a recommendation, subsequently approved by Congress, for the closure of 81 Department of Defense (DOD) installations, including MTL. A closure program was initiated by AEC, which consists of three stages: preliminary assessment/site inspection (PA/SI), RI/FS, and remedial actions. The first stage of the program at MTL, the PA/SI, was conducted by EG&G Idaho in 1987. EG&G also conducted a field program in 1988, from which an RI report was developed; however, this RI was never sent to a state or federal agency and has remained an internal draft. It was determined that chemical analyses for the 1988 sampling were not performed in accordance with the AEC Quality Assurance (QA) Program. These data could not be verified or validated by AEC and are therefore considered insupportable. Because the 1988 data are considered insupportable, a "resampling" was conducted in 1990 by ADL under contract to EG&G. This sampling was intended to duplicate, to the extent possible, the 1988 sampling effort, including resampling the 1988 sampling locations.

Resampling, however, was not possible in every case. For instance, certain aqueous sewer samples could not be collected in 1990 because no flow was present at that time.

In March 1989, AEC was assigned the responsibility for centrally managing the Base Realignment and Closure Environmental Restoration Program. As a result of the closure and realignment of MTL, additional environmental investigations were mandated prior to the sale of any MTL property. As directed by AEC, WESTON has completed RI/FS efforts (initiated by EG&G Idaho in 1988) to address issues raised by the closure and reuse of MTL. The completion of these efforts includes production of a Phase 1 RI report, performance of Phase 2 field investigation activities, and production of a Phase 2 RI report, whose conclusions and risk assessment component have incorporated all Phase 1 and Phase 2 data collected to date.

A Federal Facilities Agreement (FFA) between the Army and EPA became effective on July 24, 1995. The FFA provides the framework for the implementation of the CERCLA process at MTL. The installation was officially closed on September 29, 1995. At present, there is no firm date for the environmental cleanup and resale of the property, although it is the intention of the Army to remediate the site as quickly as possible.

1.2.2 HISTORICAL USE OF SELECTED BUILDINGS

Past use of the buildings investigated is discussed in the following subsections, with particular emphasis on potential sources of radiological or chemical contamination. Figure 1-3 depicts the locations of these buildings.

1.2.2.1 Building 36

Building 36 was erected in 1900. The building has undergone several renovations and additions and currently measures 110 ft by 275 ft long. The building has been used for manufacturing high-explosive shells and armor-piercing shells, assembling gun carriages, and storing rubber materials and gun carriage parts.

The building contains an auditorium, a library, a cafeteria, a photographic laboratory, conference rooms, and offices. There is also a mezzanine level in the library. The basement formerly held a fallout shelter.

1.2.2.2 Building 37

Building 37 is a three floor brick building built in 1851. It has undergone several additions and renovations and currently measures 131 ft by 315 ft. The building has housed several operations, including a machine shop, equipment maintenance shop, iron and brass foundry shops, an open hearth furnace, various equipment and hazardous material shops, kilns, quenching tanks, administrative offices, and general storage areas.

The first floor most recently housed an automotive repair shop, storage for lawn care equipment, a carpentry shop, a paint shop, building material storage areas, a welding facility, and automotive garages. The second floor housed the risk management offices including facility environmental coordination offices and a radiological calibration source laboratory. The third-floor area was most recently used to house the engineering plans, off-site contractors offices, and the BRAC office.

1.2.2.3 Building 39

Building 39 is a five-story building of typical reinforced concrete construction with posts 20 feet on center and typical 1920 curtain wall facade. The building was constructed in 1922 as a privately owned piano factory. It was also used as a mattress factory prior to its acquisition by the Army in 1941. In the mid-1950s, portions of the building were occupied by the U.S. Atomic Energy Commission, the U.S. Air Force Geophysics Laboratory, and the USACE Soils Laboratory and Engineering Warehouse. The types of activities performed by these agencies are unknown.

Up to 1995, the building housed numerous laboratories and offices. Research work performed in the laboratories included organic synthesis, crystallography, metals, ceramics, organic materials, corrosion, mechanics and structural integrity, computer systems, and instrument calibration operations. The offices were occupied by various research scientists, engineers, and administrative personnel.

Little is known about the early use of radioactive materials in this building. Reportedly, Room 101 on the first floor was used to melt small (40-pound) depleted uranium (DU) ingots in the 1950s. The polishing of DU was performed in Rooms 145, 146, and 147. Corrosion testing of DU was conducted in Rooms 202 and 206. A DU machine shop was located on the second floor in the area around Rooms 202, 247, and 248. The exact location is uncertain. The fifth floor contained an analytical laboratory in Rooms 501 and 512, where some DU was analyzed using wet chemical techniques and emissions spectroscopy was performed on solutions containing DU. A 1959 Nuclear Regulatory Commission (NRC) inspection report mentions nickel (Ni-63) in an hydrochloric acid (HCl) solution, H-3 (tritium) in stearic acid, and Po-210 (polonium chloride) being stored in a fume hood in the isotope laboratory of Building 39. These liquids were reportedly poured down the drain to the sanitary sewer.

In 1960, DU operations were transferred from Building 39 to other facility buildings, including Building 43.

1.2.2.4 Building 43

Building 43 is a large, high-bay, one-story brick and steel building that was originally built in 1862. The building has undergone several renovations and additions and currently measures approximately 20,000 ft^2. It was originally constructed to house a blacksmith shop. Other metal processing operations, including forging iron parts for use in seacoast gun carriages, were also performed.

In addition, the building was used for processing radioactive materials, although it was not determined when such operations were begun. The east end of the building had a concrete floor in the 1950s, but part of the floor was still dirt until the mid-1960s, when the building was used as a forge shop (MTL employee, 1992). One of the first reported uses of DU occurred in the mid-1960s, when a salt bath that was located in the southeast corner of the building was used to heat DU billets. They were extruded on the 1,000-ton press located in the northeast corner of the building (MTL employee, 1991). It is not known whether this was done before or after the dirt floor was installed. Around 1963, the melt furnace was transferred from Building 421 (in what is now the tennis/basketball courts in Arsenal Park) and installed in the annex on the north side of Building 43 (MTL employee, 1992).

Recent operations included two DU melt furnaces and a heat treat furnace in the melt room located in the annex on the north side of the building. The annex contained a lathe, a mechanical saw, and a ventilation system. The main bay of Building 43, called the Forge Shop, contained a variety of mills, presses, and ovens, some of which were used primarily for processing DU. These DU machines are located at the east end of the building, and a DU incinerator is located in the southeast corner. This DU equipment was removed by Morrison-Knudsen Corporation in the fall of 1992.

The incinerator burned DU chips and turnings. The emissions went through a scrubber and a high-efficiency particulate air (HEPA) filter and out the east end of the building. In recent times, the emissions were monitored by radiation stack monitors (MTL, 1988). The scrubber water was monitored to ensure that its concentration was less than the water effluent limits specified in 10 CFR 20 and was then poured down floor drains that discharged to the sanitary sewer (MTL, 1977).

As part of radiological decommissioning of the facility, remediation of the interior of Building 43 commenced in November 1992. Remediation included CO_2 blasting of interior surfaces, removal and disposal of the concrete floor and the drainlines beneath the floor, and soil removal (to a depth of over 10 feet bgs). Floor excavation was complete as of January 1995.

The roof of the main bay consists of two sloped sections surmounted by a V-shaped roof above a clerestory. The two sloped sections, which were originally composed of asbestos concrete, were replaced with metal panels in 1990.

1.2.2.5 Building 60

Building 60 was constructed in 1913 and 1914 as a central powerhouse and boiler room building. The boiler was originally coal-fired but was later converted to fuel oil. The plant produced electricity until 1919.

The building housed four oil-fired boilers that until May 1994 produced steam for heating other buildings in the installation. The steam was piped through underground steam tunnels to each building. During the 1994/1995 heating season, either gas or oil-fired heaters were used for heating each installation building. Plans are currently

underway for the removal of some of the Building 60 boilers. The former asbestos/cement roof was replaced with a metal roof in 1990. In April 1992, during a Phase 2 sanitary sewer investigation (WESTON, May 1994), a No. 6 fuel oil leak was detected within a sanitary sewer line located adjacent to the northwest corner of Building 60. It was determined that the leak had occurred from plumbing associated with in-tank steam heaters in the vicinity of Building 60/227 (See Subsection 1.2.2.11 for a description of structure 227). Following notification of the proper authorities, a soil removal operation was undertaken on April 30, 1992. The operation included removal of more than 175 tons of contaminated soil, 430 gallons of waste oil, 25 tons of asphalt, 1,500 pounds of oily solids, the steam heater, and associated piping. In August 1994, ABB Environmental Services (ABB-ES) performed pre-design field studies at two sites within the installation, one of which was the area of Building 60/227. The results of this work are briefly discussed in Subsections 1.2.4.3.2 and 1.2.4.3.3. However, this work was conducted under the MCP (40 CMR 40.0000), and is excluded from consideration under CERCLA, as the contamination resulted from a petroleum fuel release. Therefore the ABB-ES results are not included in the human health or terrestrial ecological risk assessments which are written in accordance with CERCLA requirements, nor are they considered when calculating soil cleanup goals and cleanup volumes in Section 2.

1.2.2.6 <u>Building 97</u>

Building 97 was constructed in 1920 and measures 56 ft by 185 ft. The building was reportedly used as a railroad locomotive repair shop. It was renovated and converted in the late 1950s to house operations associated with the nuclear research reactor.

Until 1995, the building contained various laboratories, male and female shower areas, an ion implantation facility, and a particle accelerator for neutron production.

An NRC inspection report dated 1962 indicates that radioactive by-products were being stored in the building. Liquids from the reactor and the laboratories drained to a sump in the south end of the building. The liquid was pumped to three 3,000-gallon indoor aboveground tanks. The wastewater was monitored and released to the sanitary sewer if it was determined to be below effluent limits.

A 1966 NRC inspection report discusses the Kaman neutron generator that was located in Room 145. This generator used 7-curie tritium targets. The neutron generator used a vacuum system to collect tritium (H-3). Air monitoring for tritium was being performed, but none was detected. The NRC inspection report also mentions that experiments were being performed in Room 144 using microcurie amounts of 5 to 35.

The Kaman neutron generator has been removed except for the utility connections. The liquid waste sump is present, but the three 3,000-gallon aboveground tanks have been removed to accommodate an accelerator. The water from the sump is pumped directly to a drain that discharges to the sanitary sewer.

The reactor license was terminated in October 1993. The existing facility license requires confirmation sampling of Building 97 by the NRC. Tritium washing and drainline removal were completed in December 1994.

1.2.2.7 Building 111

Building 111 was built in 1865. It is three stories tall, constructed of brick, and contains approximately 12,000 ft^2 of floor space. The building provided housing for the installation's Commanding Officer and his family. It is listed on the National Register of Historic Places.

1.2.2.8 Buildings 117 and 118

Buildings 117 and 118 were built in 1906 and 1851, respectively. The buildings were originally constructed to house cows and horses. They were later renovated and converted to provide military housing. Building 118 was also previously used to house the Post fire engine. Until recently, Building 117 was used for military housing, and Building 118 was used for military dependent housing.

1.2.2.9 Building 131

Building 131, a two-story brick building (three-story on the southwest side) containing four separate floors including a basement, was built in 1900 and expanded in 1942. It has undergone several renovations and additions and currently contains approximately 68,000 ft^2 of floor space.

The building has been used for administration since its construction. Currently, several installation administrative offices, including budget, procurement, personnel, records management, laboratory administrative offices, and technical planning offices, are located in this building. The building also contains a mail room, photo shop, print shop, and formerly contained a health clinic.

1.2.2.10 Structure 226

Structure 226 was a concrete tank vault located at the northwest corner of Building 43, and housed two 13,000-gallon heating oil tanks. The vault roof was at grade, and the vault itself was accessible from the surface through a bulkhead. The vault was of concrete construction. No known spills or releases were associated with this vault. The tanks and structure were removed in September 1993.

1.2.2.11 Structure 227

Structure 227 is a brick and concrete containment structure, housing pumping equipment and two 25,000-gallon No. 6 fuel oil tanks. Historical documents (THAMA, April 1980, and EG&G, March 1988) also list this structure as a possible source of the 1979 No. 6 fuel oil release to the Charles River although all other available historical data and information do not substantiate this source. In addition, Structure 227 was

included in the recent ABB-ES post-RI investigations (ABB-ES, December 1994) of a fuel release into the sanitary sewer system (see Subsection 1.2.2.5 for details of the ABB-ES investigation).

1.2.2.12 Structure 229

Structure 229 is a 9-ft-by-15-ft concrete building constructed in the early 1940s. It is used to house cooling oil pumping equipment. An associated 3,000-gallon underground storage tank (UST) was removed in 1991.

1.2.2.13 Building 241

Building 241 is a 26-ft-by-18-ft prefabricated metal building that was erected on an existing concrete slab in the early 1980s. The building was used for storing drums and barrels containing DU and beryllium waste products prior to off-site shipment.

1.2.2.14 Building 243

Building 243 is a 20-ft-by-30-ft brick building constructed during the 1950s. A 20-ft-by-12-ft prefabricated metal storage building was added in the 1970s. Both buildings are used for storage of various chemicals prior to laboratory use.

1.2.2.15 Structures 244 and 245

Structures 244 and 245 were propellant/explosives storage bunkers, situated side by side. The former bunkers are located near the guardhouse in the southeast corner of the site. As of the production of the Phase 2 RI Report (WESTON, May 1994) Bunker 244 was empty. An inventory of the contents of Bunker 245 at the time of production of the RI Report is provided as part of Appendix L of RI Report. It should be noted here that while Bunker 244 was empty, researchers and scientists were allowed to keep a maximum of 5 pounds of explosives in selected areas of Buildings 312 (former firing range) and 313 (former firing ranges). This was also true for the detonics lab in Building 311 until it was closed in 1992.

1.2.2.16 Building 246

Building 246 is a 30-ft-by-60-ft prefabricated metal building constructed during the 1970s. The building is used for storage of road and grounds maintenance equipment and supplies.

1.2.2.17 Building 292

Building 292 is a two-story brick building constructed in 1920. It currently measures 70 ft by 215 ft. The building was originally built as a metal stock storehouse. It was also used to house a plating shop operation. The building was renovated in the late 1950s and converted to a general laboratory building.

Until the summer of 1995, the building contained several offices and laboratories. Laboratory operations performed included X-ray diffraction, electron micrography, chromatography, and analytical wet chemistry.

It is not known when DU was first used in this building. Pieces of DU material were used in various experiments or tests, and DU was analyzed by x-ray diffraction in Rooms 205 and 212. Wet chemistry analysis involving radioactive materials was also performed in Room 212. As if April 1991, DU was no longer used in this building.

Radiological remediation of the building was completed in May 1993. The current NRC status of Building 292 is pending review of the remediation report and final termination surveys by NRC.

1.2.2.18 <u>Structure 295</u>

Structure 295 is a large concrete containment structure housing four 100,000-gallon aboveground No. 6 fuel oil tanks. Two historical documents (THAMA, April 1980 and EG&G, March 1988) refer to a possible 1970s No. 6 fuel oil spill from this structure to the Charles River. However, all other available historical data and information do not substantiate this spill. Two other fuel oil spills are known to have occurred in the early 1990s. In each case, however, the spills were contained within the concrete structure.

1.2.2.19 <u>Building 311</u>

Building 311, a large high-bay warehouse and machine shop with overhead cranes, is constructed of concrete and steel, faced with brick. The first section of the building was built in 1917 for the erection of disappearing, barbette, and railway carriages for guns. The building has had several additions and renovations and currently measures 180 ft by 950 ft.

The building has housed numerous manufacturing operations, including cold-working of guns and gun carriages, various machine shops, induction crucible furnaces, and other associated armaments research and manufacturing operations.

Recent operations included various research laboratories, an industrial X-ray facility, a detonic facility, machine shop operations, a pultrusion facility, a fiber composite lab, DU storage areas, materials receiving and warehousing areas, hazardous materials/waste storage areas, and administrative offices.

Building 311 formerly housed a radioactive materials storage area. Radioactive materials and other products were stored in metal drums in a fenced-in, open-top storage area segregated into two distinct storage compartments. A DU machine shop was once located on an area covered with steel plates in the east/central portion of the building. This was located about 100 ft from the location of the DU storage cage. DU was also stored in the DU vault and temporarily in the shipping area in the eastern part of the building. Machining operations performed on DU in this building ceased as of 1991.

Radiological remediation of Building 311, including scabbling, floor tile removal, and drainline removal was completed in November 1994. The current NRC status of Building 311 is pending review of the remediation report and final termination surveys by NRC.

1.2.2.20 Building 312

Building 312 is a high-bay brick and steel building that has three floors and was built in 1894. The building has undergone several renovations and additions and currently measures approximately 80 ft by 280 ft. It was originally built to house an erecting shop for assembling gun carriages. Additional operations that were performed in this building included a machine tool shop, an electroplating shop, a crystal growth laboratory, a shock wave physics laboratory, ballistics ranges, a mechanical equipment loft, several offices, and a laser laboratory. A section of the first floor of this building was previously used to house beryllium and DU machining operations. Activities using radioactive materials in this building are believed to have begun in 1963 when the DU machine shop was transferred from Building 421. A 1965 NRC inspection report states that DU melting and machining were being done in Building 312. It reports contamination levels of 50 to 500 dpm/100 cm^2 beta-gamma and 20 to 300 dpm/100 cm^2 alpha. The rooms that contained the DU and beryllium machine shops were constructed in 1963. Reportedly, the north part of the building continued to have a dirt floor and DU chips were stored in barrels on the floor.

Recent operations include machining DU in the south end of the first floor in the areas known as the DU and beryllium machine shops. Operations included turning, cutting, grinding, and drilling. There is also a plate shop on the first floor where DU metal was cleaned and plated. In the plate shop, small DU pieces were cleaned in buckets of nitric or hydrochloric acid or alkali. They then underwent electrochemical plating with nickel and cadmium. All work was done in an area with a concrete curb and no drain (MTL employee, 1991).

A vacuum exhaust system was installed to collect dust and particles generated by the DU and beryllium machining operations. This vacuum exhaust system is located on the third floor of Building 312 and consists of a roof stack, associated ductwork, blowers, filters, and cyclone separators.

There are currently no operations involving DU being performed in the remainder of the building. Before decommissioning operations took place in 1993/1994, the DU and beryllium machining areas had consisted of a series of small rooms (Rooms 101 through 130) with painted plaster walls and ceilings and a concrete floor covered with asphalt tile. The rooms contained various machine tools, glove boxes, sinks, and other equipment. As of the writing of this FS, all heavy maching equipment has been removed, and the floors, walls and ceilings have been remediated for radiological parameters as part of an NRC decommissioning/license termination. The plating shop is a room with a 20-ft ceiling, painted brick walls, and a concrete floor. The room contained electroplating tanks in an area with a concrete curb.

Radiological remediation of Building 312, including floor, ceiling, and trench cleaning, floor tile removal, and drainline removal was completed in September 1993. The current NRC status of Building 312 is pending review of the remediation report by NRC.

1.2.2.21 Building 313

Building 313 has two stories and a basement and was constructed in 1862 in the shape of a capital E. The building was initially used as a carriage and machine shop for gun carriage fabrication and also as a powerhouse for adjacent buildings (43 and 37). The south end of the building was also previously used as a woodworking shop. The building has had several renovations, including a second-story addition to the center wing in 1942, and currently measures 180 ft by 300 ft.

Until 1995, the building housed ballistics ranges, several research laboratories, and administrative offices. The south wing of the building contained an experimental foundry, a ceramic research and fabrication area, and a clean dry laboratory. The center wing contained a welding laboratory, the nondestructive examination (NDE) school, and associated NDE laboratories. This wing contains an abandoned cistern, located beneath the western portion of the wing, and measuring approximately 75 ft by 25 ft by 20 ft deep. The first and second floors of the north wing of the building houses the installation security offices. Also, general research laboratories, a ceramic laboratory, and other administrative offices were located there. Ballistics ranges were also located in the northeast section of the basement of this wing.

Pieces of DU were taken to Building 313, where various experiments or tests were conducted. Ballistics testing may have been performed in the building as well. Room 150A, in the center wing, was used for DU storage. There was no other known use of DU in this building.

Radiological decontamination of the cistern beneath Building 313, including the cistern floor, ceiling, and walls, was completed in October 1993. The NRC status for the cistern is pending NRC confirmation surveys.

1.2.2.22 Structures 652 and 654

These two structures are pump houses located on the southern fence line of the facility just south of Structure 295. The construction dates of the pump houses are unknown. The structures contained equipment that was used to pump water from the Charles River for use in the fire protection system. The equipment was abandoned in place when the fire water system was converted to use the municipal water supply.

1.2.2.23 Building 656

Building 656 is a 40-ft-by-30-ft single-story brick building built during the early 1960s. It contained operational cooling equipment that provided conditioned air and chilled water for Building 39. It was also used for storage of cooling equipment.

1.2.3 SITE SETTING

The information in this section provides literature and RI data regarding the environmental setting of MTL and its surroundings. This section is intended to provide the reader with a background and perspective from which to view the results of the RI and also to familiarize the reader with the contexts in which the investigation was designed. The findings of the geologic and hydrogeologic investigations of the RI (except chemical data) are also presented.

1.2.3.1 Topography and Land Use

MTL is located within the greater Boston metropolitan area, in an urbanized area of Watertown, Massachusetts, on the north bank of the Charles River. The site and surrounding area are generally flat, decreasing in elevation from approximately 36 ft above mean sea level (MSL) along the northern boundary of the facility to approximately 2.4 ft above MSL at the edge of the Charles River (Figure 1-4). The major portion of the MTL facility is situated on a low bluff approximately 25 to 35 ft above MSL, which drops off sharply just north of North Beacon Street to an elevation of approximately 15 ft above MSL. In general, most of the buildings and parking lots are located upon the northern portion of this bluff, which then slopes down to a grassy, undeveloped park area adjacent to the Charles River south of North Beacon Street.

The original, glacially formed land surface has been extensively altered by over a century of construction, demolition, and modification of buildings, roadways, and other structures in and around the MTL facility. Most, if not all, of the original topography has been covered by fill, which consists of sand and gravel and construction debris used to level the site area for the construction of buildings, parking lots, and other supporting structures. The thickness of the fill varies across the site, but based on boring logs, the average thickness is about 10 feet.

The present MTL property covers approximately 36.5 acres of land, bounded by Arsenal Street to the north, North Beacon Street to the south, commercial property to the west, and a condominium complex and small park to the east. The 11-acre area of land situated just south of MTL, between North Beacon Street and the Charles River, considered to be the property of MTL, contains North Beacon Street Park and the Watertown Yacht Club. The Army will maintain ownership of the 47.5 acres until completion of remedial activities. The Metropolitan District Commission (MDC) has been granted a right-of-way for the 11-acre parcel; this parcel will vest to the Commonwealth upon disposal of MTL. Approximately 55 acres of land to the east of the present MTL property were excessed by the U.S. government prior to 1968.

MTL is zoned for open space/conservancy (Cartographic Associates, 1989). This zoning reflects the classification to which the property would revert if sold to a nonfederal agency. The Commander's Quarters on MTL is on the National Register of Historic Places, and the facility itself has been declared a historic district.

1.2.3.2 Climate

The climate of MTL and the Boston area is affected by three major factors. First, Boston is located in a zone of prevailing west-to-east atmospheric flow. Second, Boston is situated on or near several paths that are frequently followed by low-pressure storm systems, and both polar and tropical air masses can exert an influence on the region. Finally, temperatures are moderated by the proximity of the Atlantic Ocean, although the distance from Watertown to the coast reduces this maritime effect. The freeze-free period typically ranges from early April to early November, but the inland location may shorten the freeze-free period by a week or two in the spring and a week or two in the fall.

Daytime maximum temperatures throughout the summer are generally in the 70s, with the warmest temperatures occurring in July. The mean temperature for July is 72.7 °F, with recorded extremes ranging from a high of 102 °F in 1977 to a low of 54 °F in 1986. Daytime minimum temperatures are lowest in January and exhibit a mean of 28.6 °F, with a highest recorded extreme of 63 °F in 1974 and a lowest recorded extreme of -12 °F in 1954. All of these climatic data were collected at the meteorological station at Logan International Airport, located approximately 8 miles east of MTL.

Low-pressure systems regularly pass through the region, producing precipitation approximately one day in every three. Data from 1958 through 1988 indicate a mean annual precipitation for Boston of 41.6 inches, with maximum and minimum monthly means of 3.89 inches in November and 3.12 inches in July.

The average annual wind speed for 1987 was approximately 12.4 miles per hour. The most prevalent wind direction is from the southwest, except during the months of December through March, when northwesterly winds prevail in conjunction with arctic airflow from Canada. Winds of 30 miles per hour or higher may be expected at least one day in every month. A wind rose for Logan International Airport for the 1985 to 1989 period is presented in Figures 1-5 and 1-6.

1.2.3.3 Surface Hydrology

As stated above, the MTL site slopes approximately 20 ft from the northern portion of the site to the southern boundary; therefore, the natural drainage pattern that surface runoff would follow is north to south towards the Charles River. The major segments of the stormwater collection system follow this natural drainage pattern. The majority of the minor segments, which are responsible for conveying surface runoff from cisterns and catch basins located throughout the site to the major segments of the stormwater collection system, generally run in an east-to-west direction.

One major segment of the stormwater collection system bisects the site just east of Building 656. This segment originates off-site north of Arsenal Street, enters the site on the north side of Building 311, travels southward between Buildings 656 and 292, and exits the site at the intersection of North Beacon Street and Charles River Road. A monitoring location (Background 1) was placed at the manhole north of Building 311

where this segment first enters the site. A second monitoring location (Outfall 1) was located on this segment where it exits the site at the intersection of North Beacon Street and Charles River Road. This was done to determine the net increase of flow and chemical parameters that would occur during a precipitation event. For a more complete discussion of the sewers and locations of outfalls, see Subsection 1.2.4.3.4.

The majority of surface runoff that is conveyed across the MTL site exits the site through Outfalls 1, 2, and 5.

1.2.3.4 Bedrock Geology

1.2.3.4.1 Regional Geology

The MTL facility is located within the central portion of the Boston Basin, a structurally bounded depression in Precambrian basement rock that was subsequently filled in with Cambrian-Devonian intrusive rocks (Blue Hills Block), Mississippian volcanic rocks (Mattapan Complex and Lynn Complex), and Pennsylvanian sedimentary rocks (Boston Basin Group: Cambridge Argillite and Roxbury Conglomerate) (LaForge, 1932; Billings, 1976; Kaye, 1980). A bedrock geologic map for the Boston Basin is provided in Figure 1-7.

The basin is bounded to the north and northwest by the Northern Boundary Fault, a thrust fault that forms a low-angle contact between Pennsylvanian-age Cambridge Argillite and Precambrian-age basement rocks. To the west of the site, the basin fill rocks are truncated by high-angle normal faulting. To the south of the site, the Mt. Hope, Blue Hills, and Ponkapoag thrust faults form low-angle contacts between basin fill rocks and Precambrian basement rocks. Finally, the east margin of the basin is located beneath Massachusetts Bay (Billings, 1976).

The Precambrian basement rocks have been crosscut at several locations by Cambrian-Devonian intrusive and Mississippian volcanic rocks. To the south, between the Ponkapoag and the Blue Hills thrust faults, the basement rocks are intruded by the Cambrian-Devonian-age peralkaline (sodium- and potassium-rich) Blue Hills Complex. The Blue Hills Complex includes the Quincy Granite and other felsic (silica-rich) intrusions. In the southwest portion of the basin, altered felsic and basaltic volcanics of the Mississippian-age Mattapan Complex are exposed. Volcanic rocks of similar composition assigned to the Mississippian-age Lynn Complex are exposed north of the Northern Boundary Fault. Both volcanic complexes crosscut the Precambrian basement rock and are included as clasts in the Pennsylvanian-age Boston Basin sedimentary rocks (LaForge, 1932).

The Boston Basin Group consists of two formations, the lower Roxbury Conglomerate and the upper Cambridge Argillite. LaForge (1932) subdivided the Roxbury Conglomerate into three members: the Squantum, Dorchester, and Brookline members. In general, the Roxbury conglomerate outcrops south of the Charles River and the Cambridge Argillite outcrops north of the Charles River (Kaye, 1982).

The Cambridge Argillite is typically a varved (rhythmically layered) siltstone. Beds range in thickness from 0.1 to 8 cm (0.04 to 3.1 inches) and vary from dark gray clay and silt-rich layers to light gray fine- and very fine-grained sand layers. Sedimentary structures such as graded beds, cross-bedding, ripple marks, and slump structures have been observed in the rock.

1.2.3.4.2 Structural Geology

The internal structure of the Boston Basin Group consists of a series of broad folds, plunging gently to the northeast and east (Billings, 1976). Most of the fault zones in the basin trend northeast, including the bounding thrust faults. The only major exceptions to this are the Stony Brook Fault and an unnamed fault at the southwest margin of the basin, both of which are high-angle faults and trend north-northeast and north-northwest, respectively. The Stony Brook Fault is mapped from Fresh Pond, approximately 2 miles east of the MTL, and runs south-southeast for approximately 20 miles.

The MTL site is located on the northern arm of the Charles River syncline, one of the broad folds within the Boston Basin Group. The syncline axis has an east-west orientation and is located beneath the channel of the Charles River as it flows by the MTL site. The syncline has subsequently been filled in with Quaternary and recently deposited unconsolidated sediments. At the point where the Charles River flows past the site, the syncline axis is believed to reach a maximum depth of up to 190 ft below ground surface (bgs) (Chute, 1959).

1.2.3.4.3 Site-Specific Bedrock Geology

Based on mapping conducted by Billings (1976), the Pennsylvanian-age Cambridge Argillite underlies the entire MTL facility. Geophysical results from a seismic refraction survey conducted by Weston Geophysical Corporation of Weston, Massachusetts (not affiliated with Roy F. Weston, Inc.), during the Phase 1 RI were used to estimate depths to bedrock and construct a bedrock contour map (Figure 1-8). Based on the seismic survey, depth to bedrock was believed to range from slightly less than 50 ft to approximately 140 ft.

Prior to the start of the Phase 2 study, little soil boring information providing confirmed depths to bedrock was available. In 1985, Goldberg-Zoino Associates, Inc. (GZA), of Newton, Massachusetts, completed eight soil borings in a parking lot south of Building 36. The borings were to be used to provide geotechnical information for a proposed research facility that was never built. Bedrock was not encountered in any of the borings; however, two borings were drilled to approximately 80 ft without encountering refusal, indicating that depth to bedrock in this area is at least 80 ft. This result supports the Phase 1 geophysical work, which suggests that depth to bedrock in this area is in the 80-to-95-ft range. During the Phase 1 RI, one well, C-1, encountered bedrock at 61.5 ft. This depth to bedrock closely agreed with the 57-ft depth that was projected based on geophysical survey results.

During the Phase 2 RI, four on-site wells, MW-21, MW-15A, MW-17A, and MW-19A, encountered refusal that was assumed to be bedrock. With the exception of MW-19A, all refusal depths agreed to within 5 to 10 ft of the depths projected based on the Phase 1 geophysical study. MW-19A was drilled in what is believed to be (based on geophysics) the area of the deepest bedrock on the site. Phase 1 geophysical results had suggested that depth to bedrock in this area is in the 140-ft range, although rock was encountered in MW-19A at 98 ft bgs. Bedrock at MW-19A was confirmed by drilling an additional 14 ft through rock with an air hammer. This drilling result indicates that the geophysical survey overestimates the depth to bedrock in this portion of the site. One off-site well, MW-16A, encountered rock refusal at 41 ft, suggesting that the depth to bedrock decreases to the northwest moving away from the site. This drilling result agrees with surficial geologic mapping (Chute, 1959), which reports thinning and eventual loss to the outwash and the clay/fine sand layers moving northeast from the site.

Based on drilling results from the Phase 2 RI and on Phase 1 RI geophysics, estimates of depths to bedrock are provided in Figure 1-8. These estimates assume that the general shape of the bedrock surface determined by geophysics is correct; however, adjustments of depth to bedrock were made based on bedrock depths confirmed by Phase 2 drilling.

Based on a rock coring obtained at boring C-1 during the Phase 1 RI, the Cambridge Argillite beneath the site was described as follows:

> The recovered core from the Cambridge Argillite shows that it is highly folded beneath the MTL. The drill core axis is nearly parallel to the bedding in the drill core sample, indicating the originally horizontal bedding has folded to a vertical orientation (EG&G, 1990).

1.2.3.5 <u>Soil and Surficial Geology</u>

1.2.3.5.1 Regional Surficial Geology

The unconsolidated materials within and surrounding the MTL site were deposited as a result of glacial activity primarily during the advance and retreat of the last ice sheet that covered the region (Chute, 1959). The sequence of sediments includes glacial till, lake deposits composed of clay interbedded with some fine sand and gravel, outwash deposits of sand and gravel with some fine material, and recent deposits.

The sequence of unconsolidated sediments can best be understood by taking into consideration the history of the most recent glacial event that took place in this region. The oldest unconsolidated material is a lodgement till laid down during the advance of this most recent ice sheet. The till is believed to consist of a thin veneer of poorly sorted material with thicker deposits in valleys. On a regional scale, little is known about the thickness and distribution of the till, and it may even be absent in some areas. The thickness of this deposit is a function of postdeposition erosion activity.

Following retreat of the ice sheet, ponded meltwater filled in low-lying areas and deposited clay with some sand and gravel mixed in. Deposition ended when a short readvancement of the ice sheet caused ponded water to drain. As the ice sheet readvanced, it also scraped up the fine-grained deposits, thereby forming the Fresh Pond Moraine, an end moraine located approximately 1 mile northeast of the site. The MTL site is located downgradient of the end moraine, and in this area, the fine-grained materials were not removed by the readvancing ice. In front of the advancing ice sheet, sand and gravel and, to a lesser extent, minor quantities of fine-grained material were deposited as outwash on top of the previous fine-grained meltwater deposits. Deposited on top of the outwash are sandy and silty loam, fill material, and peat, each a result of postglacial activity.

The soil at MTL is classified by the Soil Conservation Service as Merrimack gravelly sandy loam, although the entire area falls generally within an "urban land" designation. Soils at MTL have been extensively altered during the history of the facility by various construction activities. Extensive excavation and backfilling have made it difficult to find sections of native soil.

1.2.3.5.2 Site-Specific Surficial Geology

The surficial geology at MTL has been investigated since 1958, first for its water supply potential, which is described in two reports (NED, 1958; Layne, 1958). More recently, in 1987, GZA completed a geotechnical study to investigate a parking lot south of Building 36. Eight borings were completed. The most recent geologic and hydrogeologic work has focused on assessing soil and groundwater contamination resulting from activities at the MTL facility.

In general, the overburden deposits consist of (in ascending order) basal glacial till directly overlying bedrock, silty clay with some fine sand and gravel, interlayered outwash deposits of sand and gravel with some fine materials, and finally, more recent deposits and fill near the surface.

Based on soil boring and geophysical information, the total thickness of these unconsolidated materials is thought to range from just under 50 ft near the northwest corner of the site to approximately 95 ft in the area near MW-19A on the eastern side of site. Rock refusal was encountered in MW-16A at 41 ft bgs, indicating that unconsolidated material becomes thinner moving off-site to the northwest. Moving south of the site towards the Charles River, no deep wells or borings were completed near the Charles River; however, depth to bedrock is thought to increase approaching the axis of the Charles River syncline (Chute, 1959).

Based on field observation from soil boring results, the distribution of surficial units at MTL was found to be highly variable; however, it is possible to characterize changes in thickness and distribution of geologic material. Based on both Phase 1 and Phase 2 soil boring logs, two geologic cross-sections were constructed to illustrate the distribution and thicknesses of surficial geologic units at MTL (Figures 1-9, 1-10, and

1-11). A discussion of the distribution of unconsolidated materials as observed in cross-sections is provided below.

During previous studies, the lowest stratigraphic unit (glacial till) was encountered in three soil borings at the site (C-1, C-3, and B-6) and fully penetrated only one boring, C-1. In boring C-1, the till was approximately 8 ft thick and was encountered at a depth of 61 ft. Although no split-spoon samples were retrieved from boring C-1, drilling cuttings included subrounded cobbles of granitic bedrock and subangular fragments of Cambridge Argillite. In boring C-3, the till consisted of gray-green silt-rich gravel with angular rock fragments and medium- to coarse-grained sand. Although the boring penetrated only 2 ft into till at this location, from a depth of 37.5 to 39.5 ft, the till thickness was inferred by previous investigators (EG&G, 1990) to be approximately 25 ft, based on the seismic refraction profiles. In boring B-6, 2 ft of glacial till, consisting of a dense brown clayey, silty sand with gravel, was penetrated from a depth of 76 to 78 ft.

During the Phase 2 RI, all six deep monitor wells (MW-15A, MW-16A, MW-17A, MW-19A, MW-20, and MW-21) encountered till, with thicknesses ranging from 7 to 42 ft. The 42-ft thickness was reported at MW-19A, where Phase 1 seismic refraction results suggest that a bedrock trough exists. Composition of till ranged from predominantly clay and silt, with low percentages of sand and gravel (MW-15A and MW-17A), to between 30 and 50% sand and gravel, with low percentages of clay and silt, at the eastern end of the site (MW-19A and MW-20). Deep wells located in the middle and western portions of the site (MW-15A, MW-17A, and MW-21) showed slow recharge rates and were typically pumped dry during well development. Deep wells on the eastern end of the site (MW-20 and MW-19A) showed quicker recharge rates and were not pumped dry during well development.

Above the glacial till deposits, which appear, based on soil boring logs, to be continuous over the entire site, a predominantly silt-and-clay unit was encountered in all but four borings. This material is presumed to have been deposited by ponded meltwater that accumulated during retreat of the most recent ice sheet. The silty sand was not encountered at the eastern edge of the site in MW-7 or MW-8, which were installed during the Phase 1 RI, or in MW-19A and MW-20. The fine-grained meltwater deposits range in thickness from nonexistent to 58 ft in MW-17A. It is difficult to conclude with absolute certainty why the meltwater deposits become thinner and eventually disappear moving to the east. This disappearance is possibly the result of postdepositional erosion that may have occurred during deposition of upper sand and gravel outwash deposits. Cobbles and coarse sand were reported at the eastern end of the site within the outwash. This indicates that at some point during deposition of outwash, water velocities were very high. In general, the full thickness of this unit is water-saturated, except in the northern third of the site, where the upper 5 to 10 ft of the silty sand may be unsaturated, as indicated by the groundwater levels shown on the geologic cross-sections.

Above the fine-grained meltwater deposit, a sand unit was encountered across the site. Absent from the northwestern corner of the site, as shown by boring logs MW-10, C-1,

and MW-14, this unit becomes thicker and generally coarser grained towards the east. It is characterized as a fine-to-coarse sand and gravel, with cobbles also present on the eastern portion of the site. This unit is the outwash deposit that was laid down during the advance of the most recent ice sheet.

Above Quaternary deposits at the southeastern boring location C-3, and at borings located on the south side of Beacon Street, peat was encountered above the silty sand unit. This peat is believed to represent a buried swamp previously adjacent to a former channel of the Charles River. Other borings (MW-11 and MW-6) constructed at the same elevation as C-3 with respect to the Charles River did not encounter peat, further suggesting that the peat deposits are probably limited in areal extent.

Fill material with widely varying characteristics is found over the entire site. The fill ranges from fine sand to coarse sand and gravel, with building debris (bricks, concrete, cinders or slag, and wood) mixed in at a number of locations. The fill is reported to range in thickness from a few feet to approximately 20 ft (at MW-4). Typically, fill was interpreted to be in the 5-to-8-ft-thick range, which is consistent with most of the foundation design requirements for structures at MTL. At many locations, however, fill was difficult to distinguish from the underlying outwash, particularly along eastern and southern portions of the site where both the native and fill materials consist of medium-to-coarse sand and gravel.

1.2.3.6 Hydrogeology

Interpretation of hydrologic conditions at MTL is based on analysis of geologic and hydrologic data from soil borings and monitor well installations, water-level measurement data, and aquifer hydraulic conductivity test results (slug tests). The hydrogeologic setting determines the occurrence and migration of groundwater and is a fundamental factor influencing installation water quality.

1.2.3.6.1 Regional Hydrogeology

Sufficient information exists to discuss relationships only within the unconsolidated glacial sediments at MTL. While it is recognized that the underlying bedrock (Cambridge Argillite) is probably a separate hydrologic unit, there is little available hydrogeologic information available on the bedrock. Based on the geologic setting, the fact that several reservoirs in the Massachusetts Water Resources Authority (MWRA) comprise the source of public water supply and the urbanized environment in which the MTL site is located, it is probable that groundwater occurrence and flow within bedrock is of limited significance in relation to human receptors; therefore, hydrogeologic properties of the bedrock will not be evaluated as part of the assessment of site hydrology.

The MTL site is located on the northern limb of the Charles River syncline, a buried valley that forms the channel for the Charles River as it flows past the site. Topographically, land surface elevations increase traveling away from the site to the north and to the south on the opposite side of the Charles River (Figure 1-2,

Topographic Map). Investigation results indicate that regional hydrology is generally controlled by the physiographic setting, with regional groundwater flow away from the topographic high areas and towards the Charles River. On the northern side of the Charles River, regional groundwater flows generally in a southerly direction across the site towards the river. On the southern side of the Charles River, regional groundwater is believed to flow generally in a northerly direction, also towards the river.

1.2.3.6.2 Site-Specific Hydrogeology

Water-level measurements collected for the Phase 2 work were used to characterize groundwater conditions. Based on these measurements, piezometric surface contour maps were developed for shallow and deep wells. Water-level data are summarized in Table 1-1. Data collected over several months during the Phase 1 study were used to evaluate seasonal variations in water levels.

1.2.3.6.3 Water Table Configuration

In general, depth to groundwater is within 5 to 10 ft of the land surface along the southeastern boundary of the facility adjacent to the Charles River. Depth to groundwater reaches a maximum of approximately 30 ft bgs along the eastern boundary of the site, where the ground surface reaches its maximum elevation and coarse-grained deposits allow rapid soil drainage. Depth to groundwater in the central portion of the facility is on the order of 15 to 20 ft bgs for shallow wells and 20 to 25 ft bgs for deep (A-series) wells.

Variations in groundwater flow direction and velocity may occur as a result of fluctuations in water level. Groundwater data collected monthly between 8 February 1990 and 31 August 1990 as part of the Phase 1 RI were used to assess seasonal variations in groundwater flow. The groundwater data indicate that flow paths across the site are not significantly influenced by seasonal variations in groundwater level. Groundwater elevations were generally lower for summer months (resulting from lower recharge during the summer); however, lower groundwater levels were consistent throughout the entire site and, as a result, there was little significant change in flow direction or horizontal hydraulic gradient. Because the historical groundwater data used to establish seasonal trends were collected before installation of well couplets, no seasonal assessment of seasonal variations in vertical hydraulic gradient could be made.

Groundwater data collected for the Phase 2 RI were used to develop separate piezometric surface contour maps for the deep and shallow wells at the site (Figures 1-12 and 1-13). Phase 2 data made use of 15 additional wells (31 wells total), which provided greater detail on groundwater flow in the following areas:

- Along the upgradient (northern) boundary of the site
- Along the downgradient (southern) boundary of the site
- Within the deeper groundwater immediately above bedrock

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Table 1-1

Groundwater Level Summary

Well ID	Ground Elevation[a]	TOC Elevation[b]	09 Dec 91		24 Jan 92		6 March 92	
			Level	Elevation	Level	Elevation	Level	Elevation
C-2	37.49	37.04	30.65	6.39	30.95	6.09	31.20	5.84
C-3	11.90	11.44	7.86	3.58	8.16	3.28	8.09	3.35
MW-1	24.98	24.11	5.78	18.33	5.87	18.24	6.15	17.96
MW-2	24.04	23.59	8.84	14.75	8.35	15.24	9.16	14.43
MW-3	36.63	36.14	22.42	13.72	22.43	13.71	22.97	13.17
MW-4	36.52	35.90	28.65	7.25	28.52	7.38	28.87	7.03
MW-5	15.93	15.24	8.80	6.44	8.63	6.61	8.94	6.30
MW-6	11.96	11.52	7.13	4.39	7.10	4.42	7.44	4.08
MW-7	34.84	34.16	29.40	4.76	29.49	4.67	29.78	4.38
MW-8	39.48	38.89	32.70	6.19	32.87	6.02	33.08	5.81
MW-9	37.03	36.63	14.24	22.39	14.65	21.98	15.20	21.43
MW-10	32.86	32.10	8.37	23.73	9.18	22.92	9.76	22.34
MW-11	11.01	10.59	4.70	5.89	4.54	6.05	5.04	5.55
MW-12	38.52	38.07	31.87	6.20	32.13	5.94	32.30	5.77
MW-13	35.30	34.70	11.76	22.94	12.05	22.65	12.21	22.49
MW-14	35.49	35.06	15.46	19.60	13.90	21.16	16.43	18.63
MW-15	34.85	34.04	15.40	18.64	15.55	18.49	16.03	18.01
MW-15A	34.90	34.09	24.58	9.51	24.27	9.82	25.00	9.09
MW-16	34.40	33.45	12.22	21.23	12.63	20.82	12.73	20.72
MW-16A	34.76	33.91	18.85	15.06	18.38	15.53	19.36	14.55
MW-17	32.75	31.80	19.40	12.40	19.38	12.42	20.23	11.57
MW-17A	33.02	32.10	23.80	8.30	23.73	8.37	24.11	7.99
MW-18	22.89	22.13	16.35	5.78	16.19	5.94	16.41	5.72
MW-19	35.77	34.87	30.00	4.87	30.27	4.60	30.45	4.42
MW-19A	35.81	34.97	30.20	4.77	30.53	4.44	30.65	4.32
MW-19B	35.72	34.87	30.23	4.64	30.60	4.27	30.80	4.07
MW-20	39.49	38.49	32.47	6.02	32.79	5.70	32.95	5.54
MW-21	24.96	23.85	14.75	9.10	14.14	9.71	15.17	8.68
MW-22	30.54	29.80	13.05	16.75	12.94	16.86	13.26	16.54
MW-23	36.70	35.98	12.79	23.19	12.58	23.40	13.30	22.68
MW-24	31.76	30.92	8.20	22.72	7.92	23.00	8.69	22.23

[a]All elevations referenced to National Geodetic Vertical Datum of 1929 (NGVD).
[b]TOC indicates top of 4-inch PVC casing.
Note: All measurements in feet.

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Table 1-1

Groundwater Level Summary (Continued)

Well ID	Ground Elevation[a]	TOC Elevation[b]	20 Jan 95		31 May 95		23 Aug 95	
			Level	Elevation	Level	Elevation	Level	Elevation
C-2	37.49	37.04	31.10	6.00	31.30	5.70	NA	NA
C-3	11.90	11.44	12.00	-0.60	8.50	2.90	9.00	2.40
MW-1	24.98	24.11	7.00	17.10	5.30	18.80	7.50	16.60
MW-2	24.04	23.59	9.90	13.70	8.30	11.70	10.70	12.90
MW-3	36.63	36.14	23.80	12.40	24.40	11.70	18.70	17.40
MW-4	36.52	35.90	30.10	5.80	30.40	5.50	29.50	6.40
MW-5	15.93	15.24	9.30	6.00	8.10	7.10	12.60	2.70
MW-6	11.96	11.52	12.00	-0.50	8.50	3.00	9.20	2.30
MW-7	34.84	34.16	31.10	3.10	30.30	3.90	32.00	2.20
MW-8	39.48	38.89	36.10	2.80	33.10	5.80	38.00	0.90
MW-9	37.03	36.63	12.60	24.00	14.50	22.10	14.00	22.60
MW-10	32.86	32.10	10.30	21.90	9.10	23.00	10.40	21.70
MW-11	11.01	10.59	4.30	6.30	6.00	4.60	7.50	3.10
MW-12	38.52	38.07	31.30	6.70	31.80	6.30	34.50	3.60
MW-13	35.30	34.70	11.30	23.40	11.10	23.60	13.00	21.70
MW-14	35.49	35.06	16.90	18.10	17.00	18.10	18.20	16.90
MW-15	34.85	34.04	15.30	18.80	16.30	17.70	17.20	16.80
MW-15A	34.90	34.09	20.90	13.20	29.00	5.10	25.20	8.90
MW-16	34.40	33.45	11.60	21.90	14.00	19.50	15.00	18.50
MW-16A	34.76	33.91	18.80	15.20	19.20	14.70	23.00	10.90
MW-17	32.75	31.80	43.40	-11.60	45.50	-13.70	43.10	-11.30
MW-17A	33.02	32.10	22.30	9.80	19.00	13.10	22.80	9.30
MW-18	22.89	22.13	22.80	-0.60	17.00	5.10	12.80	9.30
MW-19	35.77	34.87	31.30	3.60	30.00	4.90	31.50	3.40
MW-19A	35.81	34.97	31.20	3.80	31.80	3.20	32.60	2.40
MW-19B	35.72	34.87	34.80	0.10	31.50	3.40	33.10	1.80
MW-20	39.49	38.49	33.80	4.70	35.10	3.40	33.50	5.00
MW-21	24.96	23.85	14.60	9.30	15.00	8.90	17.10	6.80
MW-22	30.54	29.80	12.20	17.60	12.50	17.30	14.00	15.80
MW-23	36.70	35.98	13.70	22.30	14.10	21.90	15.00	21.00
MW-24	31.76	30.92	7.80	23.20	8.90	22.00	11.00	19.90

[a]All elevations referenced to National Geodetic Vertical Datum of 1929 (NGVD).
[b]TOC indicates top of 4-inch PVC casing.
Note: All measurements in feet.

As shown in the Phase 2 piezometric surface maps for both shallow and deep wells (Figures 1-12 and 1-13), the general groundwater flow direction is south-southeast towards the Charles River. Groundwater was expected to flow in this direction based on the regional physiographic setting. Approaching the river, groundwater contours within shallow wells generally parallel the north bank of the Charles River, clearly showing that the river is influencing shallow groundwater flow. In addition, the surveyed river water elevation is lower than the surrounding groundwater elevation in the Charles River, indicating that the hydraulic gradient drives shallow groundwater into the river.

In the northwest portion of the study area, along Arsenal Street, water-level data suggest local mounding is creating a groundwater flow component towards the north. The three rounds of water-level measurements collected in December 1991 and January and March 1992, as part of the Phase 2 RI, showed differences in the degree of groundwater mounding occurring. Mounding was greatest in December 1991, probably due to heavy rainfall that occurred during that period. Water-level measurements collected in January and March of 1992 show less mounding in the northwest portion of the study area. The initial groundwater contour map (Figure 1-12, based on the December 9, 1991 data) indicated the mound runs in a roughly linear, east-west orientation. Although the exact location of the crest of the mound is not known, two possible locations for the mound were considered during the Phase 2 RI. The first potential location is south of wells MW-10 and MW-13 along the northwest corner of the site. If this is where the mound is located, then contaminants generated in the northwest corner of the site, including inside Buildings 246 and 311, could potentially migrate off-site to the north, towards what were previously identified as upgradient wells MW-24, MW-16, and MW-16A. This mound configuration is unlikely for the following reasons:

- It is difficult to develop a reasonable groundwater contour map with the crest of the mound located south of wells MW-10 and MW-13. The hydraulic gradient between the crest of the mound and downgradient well MW-14 (where the water level was measured at 19.6 ft in December 1991) would be extremely steep, much steeper than in any other part of the study area.

- The ground surface in this area is covered by Building 311 and by an asphalt parking lot located west of Building 311; therefore, overhead precipitation recharge to maintain the mound will not occur.

An alternative groundwater mound location is north of wells MW-10 and MW-13 along Arsenal Street. This location is a more likely for the following reasons:

- It is much easier to develop a plausible groundwater contour map with a mound located in this area. Hydraulic gradients encountered would not be unreasonably steep as was the case when assuming a mound location south of wells MW-10 and MW-13.

- Surface cover in this area consists of grass, which would allow for infiltration of overhead recharge; underground utility pipes running along Arsenal Street provide another potential source of groundwater recharge.

Since the completion of the Phase 2 RI, a water main leak of unknown duration was discovered along Arsenal Street, and was initially considered to be a possible source of recharge for the groundwater mound in the northwest corner of the study area. The water main leak was repaired by the Massachusetts Water Resources Authority (MWRA) prior to 1995. The MTL installation has been monitoring groundwater levels on a monthly basis since the completion of the Phase 2 RI. The measured water levels and elevations for three recent monitoring events are included on the second page of Table 1-1. Recent groundwater contour maps for the water table wells are shown in Figures 1-14 (January 20, 1995 water level elevations) and 1-15 (August 23, 1995 water level elevations). In both figures, the presence of a mound is still indicated by the identical water level contours on either side (north and south) of MW-13 (with a groundwater crest assumed to be located between the identical contour lines). The fact that a mound still exists is indicative that the water main leak was not the source (or at least not the sole source) of recharge for the mound. However, the recent groundwater level measurements do not provide any compelling evidence to dispute that the crest of the mound is likely to be located north of both MW-10 and MW-13, as determined in the Phase 2 RI.

Because the probable location of the peak of the mound observed in the northwest portion of the study area is north of wells MW-10 and MW-13 (based on both Phase 2 data, and on more recent 1995 data), it has been determined that no opportunity exists for contamination from on-site sources, particularly in Building 311, to migrate off-site northward toward areas identified as upgradient.

Figure 1-16 provides hydrographs for the 1995 groundwater level measurements acquired by the installation. For the wells in the northwest corner of the study area (MW-10, MW-13, MW-16, MW-16A, and MW-24), it is evident that there is little seasonal variability in groundwater levels (less than five feet), both for individual wells and for relative differences in groundwater levels among the wells. Therefore, it can be concluded that seasonal variations in water levels would not have any significant impact on the presence or location of the mound in the northwest corner of the study area.

Within deep wells, groundwater contours show that flow is again to the southeast toward the river; however, because there are fewer deep wells available, the exact shape of the deep groundwater contours as they approach the Charles River are not clearly understood. As a result, it is difficult to conclude with certainty how the river affects deep groundwater flow and whether deep groundwater is flowing into the river or is continuing to flow in a southeast direction beneath the river, eventually ending up in Boston Harbor.

1.2.3.6.4 Hydraulic Gradients

A comparison of water-level measurements across the site was used to assess both horizontal and vertical hydraulic gradients. Vertical gradients were evaluated by comparing shallow and deep water elevations at well clusters in the following locations: MW-15/MW-15A, MW-16/MW-16A, MW-17/MW-17A, MW-8/MW-20, and MW-19/ MW-19A.

Using the equation that shows that hydraulic gradient is equal to the ratio of change in head between two points to distance between those two points, vertical hydraulic gradients have been calculated between shallow and deep well screens for each well cluster. Vertical groundwater flow gradients are presented for each well cluster in Table 1-2.

In general, at the time water-level measurements were collected, water levels in shallow wells were several feet higher than in complementary deep wells. This indicates that a strong downward vertical gradient exists over most of the site. This situation provides a potential for contaminated shallow groundwater to migrate to the deeper zone. An exception to this general strong downward hydraulic gradient is the eastern portion of the site, where the head in the shallow and deep wells is nearly equal, indicating that flow between the shallow and deep groundwater is less restricted in this area than in other portions of the site.

The reason for the low vertical gradient in the eastern portion of the site is related to the coarse-grained materials found throughout the stratigraphic column. The coarse-grained materials allow for good hydraulic connection between the shallow and deep sediments, and the head in sediments is therefore nearly equal. For the remainder of the site, the opposite is true. Deep, low-conductivity fine sediments act as a barrier that impedes downward groundwater percolation. During wet periods, infiltrated water mounds in shallow sediments.

Horizontal hydraulic gradients were evaluated for both shallow and deep monitor wells. Gradients evaluated for shallow groundwater between the northern site boundary and the Charles River ranged from 0.010 at the eastern end of the site to 0.023 at the western end of the site. The reason for the difference in gradients between the two ends of the site is again the difference between the hydraulic conductivities of the sediments. At the eastern end of the site, hydraulic conductivity of sediments is high, and as a result, precipitation recharge is transmitted quickly through sediments. This situation results in a relatively low amount of groundwater mounding and flat hydraulic gradients. At the western end of the site, hydraulic conductivity is low and precipitation recharge is not transmitted quickly; this causes mounding of groundwater and steep hydraulic gradients. Flow paths used to compute hydraulic gradients are identified in Figure 1-13 as Flow Path A and Flow Path B for the eastern and western ends of the site, respectively.

Within deep wells, computation of hydraulic gradient was completed for groundwater flowing south-southeast between the northern and southern boundaries of the site.

Table 1-2

Hydraulic Gradient Summary

Couplet	Vertical Flow Gradients				Comments
	Water Elevation[a]		Vertical Distance[b] (ft)	Vertical Gradient	
	Shallow (ft)	Deep (ft)			
MW-15/MW-15A	18.64	9.51	32.1	0.284	
MW-16/MW-16A	21.23	15.06	9.6	0.643	
MW-17/MW-17A	12.40	8.30	40.0	0.102	
MW-19/MW-19A	4.87	4.64	58.8	0.0039	

Location	Horizontal Flow Gradient			Comments
	Change in Elevation[a] (ft)	Horizontal Distance (ft)	Horizontal Gradient	
Shallow aquifer, eastern part of site	20.8	890	0.023	See Flow Path A, Figure 1-13.
Shallow aquifer, western part of site	17.9	1,740	0.010	See Flow Path B, Figure 1-13.
Deep aquifer, middle of site	8.0	975	0.008	See Flow Path, Figure 1-12.

[a] Water elevations based on water-level measurements obtained December 9, 1991.
[b] Vertical distance taken as the distance between the midpoints of upper and lower well screens.

Because of the limited number of wells, hydraulic gradient was computed for only one flow path (identified as Flow Path on Figure 1-12). The hydraulic gradient, computed across the site for the deep aquifer, is 0.0082.

1.2.3.6.5 Hydraulic Conductivity

During the Phase 1 RI, in situ hydraulic conductivity testing was performed at MW-1 through MW-14 and at monitor well C-2. In addition, laboratory hydraulic conductivity testing of soil samples collected at the following five monitor well locations was completed: C-1, C-3, MW-1, MW-2, and MW-14. Test results are summarized in Table 1-3. The following general comments may be made about the Phase 1 slug test results:

- Some of the hydraulic conductivity test results may be biased high, since testing and analysis were performed on monitor wells that were screened across the water table.

- Some wells were screened across more than one geologic unit, and as a result, conductivity results will apply to the more conductive unit.

- No hydraulic conductivity of the glacial till was obtained, as no wells from the Phase 1 RI were screened in the till.

To reduce data gaps in Phase 1 slug test results, WESTON completed a limited number of slug tests during the Phase 2 RI. Phase 2 hydraulic conductivity testing was completed at the following well cluster locations: MW-15/MW-15A, MW-16/MW-16A, MW-17/MW-17A, and MW-19/MW-19A. By using the well clusters, conductivity of till could be evaluated, and a comparison of deep versus shallow hydraulic conductivity could be made at each location.

To reduce problems associated with results biased by the presence of an unsaturated filter pack in shallow wells, slugs were placed in shallow wells, and water levels in wells were allowed to recover for several hours. Following complete water-level recovery, slugs were pulled from wells, and the rate of water-level recovery was measured. For shallow wells, only the rising portion of the slug test was used. Slug test results are presented in Appendix E of the Phase 2 RI Report, and a summary is presented in Table 1-4. Based on WESTON's slug test results, the following general comments may be made about site hydraulic conductivity:

- Hydraulic conductivity results for shallow sediments (outwash) are in the range of 0.4 to 0.9 ft/day. These values remain consistent throughout the site.

- Upgradient of the site, test results for MW-16 suggest that hydraulic conductivity of shallow (outwash) sediments is greater than on-site (3.9 ft/day). This conclusion is supported by observations made during development of upgradient shallow wells MW-22, MW-23, MW-24, and MW-16. In general, a greater pumping rate was used for these wells than

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Table 1-3

Phase 1 Hydraulic Conductivity Summary

Monitor Well	Strata	Hydraulic Conductivity (cm/sec)		
		Rising Head	Falling Head	Laboratory
C-1[a]	Silty sand	—	—	2.2×10^{-6}
C-2	Silty sand	9.53×10^{-3}	3.35×10^{-2}	—
C-3	Silty sand	9.53×10^{-3}	9.18×10^{-3}	1.0×10^{-7}
MW-1	Medium coarse sand	1.20×10^{-2}	2.75×10^{-2}	2.5×10^{-7}
MW-2	Fine coarse sand	2.82×10^{-2}	3.53×10^{-3}	1.5×10^{-6}
MW-3	Silty sand	4.24×10^{-2}	*	—
MW-4	Fine coarse sand	2.47×10^{-2}	*	—
MW-5	Silty sand	1.34×10^{-2}	*	—
MW-6	Silty sand	1.06×10^{-2}	1.06×10^{-3}	—
MW-7	Fine coarse sand	6.35×10^{-2}	*	—
MW-8	Medium sand	3.32×10^{-2}	1.66×10^{-2}	—
MW-9	Silty sand	4.24×10^{-3}	3.04×10^{-2}	—
MW-10	Medium sand	4.24×10^{-3}	6.71×10^{-3}	—
MW-11	Silty sand	7.06×10^{-4}	1.41×10^{-3}	—
MW-12	Fine medium sand	3.00×10^{-2}	6.00×10^{-2}	—
MW-13	Fine coarse sand	2.29×10^{-2}	3.07×10^{-2}	—
MW-14	Silty sand	1.09×10^{-2}	*	6.0×10^{-7}

— Indicates laboratory test could not be run.
* Indicates erratic or insufficient data or insufficient displacement of water level.
[a]Well not installed.
(Source: EG&G, June 1990)

Table 1-4

Phase 2 Hydraulic Conductivity Summary

Monitoring Well	Hydraulic Conductivity				Test Type
	Bouwer & Rice (1976)		Hvorslev (1951)		
	(ft/day)	(cm/sec)	(ft/day)	(cm/sec)	
MW-15	1.14	4.02E-04	1.83	6.5E-04	Rising head
MW-15A	0.09	3.2E-05	0.12	4.3E-05	Falling head
MW-15A	0.06	2.1E-05	0.08	2.8E-05	Rising head
MW-16	3.90	1.4E-03	6.60	2.3E-03	Rising head
MW-16A	0.79	2.8E-04	1.50	5.3E-04	Falling head
MW-16A	0.61	2.2E-04	1.10	3.9E-04	Rising head
MW-17	0.33	1.16E-04	0.51	1.8E-04	Rising head
MW-17A	0.04	1.4×10^{-5}	0.05	1.8E-05	Falling head
MW-19	0.93	3.3E-04	1.60	5.6E-04	Rising head
MW-19A	62.29	2.2E-02	14.46	5.1E-03	Falling head
MW-19A	77.20	2.7E-02	39.60	1.4E-02	Rising head

Note: Hydraulic conductivity computer by Bouwer & Rice (1976) used for prediction of groundwater velocities.

for the shallow on-site wells. Increased conductivity (i.e., grain size) of outwash sediments traveling north from the site corresponds to the surficial geologic model of the region; coarse-grained sediments would be expected upgradient of the site because this area is believed to be closer to the original depositional source.

- Hydraulic conductivity of deep wells MW-15A and MW-17A was an order of magnitude lower than the shallow wells, ranging from 0.04 to 0.09 ft/day. MW-15A and MW-17A are screened across two formations: the upper predominantly silt and clay ponded water deposits and the lower glacial till. Slug test results would represent a composite conductivity of the two; however, the test results would be biased towards the more conductive unit. Therefore, it could be concluded that at locations MW-15A and MW-17A, the hydraulic conductivities of both silt and clay and glacial till are very low.

- Hydraulic conductivity results from MW-19A suggest that the conductivity of the deeper portion of the aquifer in the eastern portion of the site is as much as two orders of magnitude greater than deep sediments at other portions of the site. The recharge rate observed during development of MW-20 also supports the conclusion that there is increased conductivity in deep sediments on the eastern side of the site.

1.2.3.6.6 Groundwater Velocity and Travel Times

Based on hydraulic conductivity results for shallow monitor wells located at the downgradient (southern) MTL property boundary and hydraulic gradients computed from December 1991 monitor well water-level measurements, flow paths between shallow wells MW-1, MW-2, MW-5, MW-6, MW-11, MW-17, and MW-18 and the Charles River were determined, and groundwater travel times between each well and the river were calculated. Groundwater flow paths for the shallow wells are shown in Figure 1-13, and travel times are summarized in Table 1-5. All hydrogeologic data used to compute travel times were obtained within the MTL facility; therefore, travel time calculations assume that hydrogeologic properties in the area between the site and the Charles River, for which no hydrogeologic data exist, are similar to those on the site.

Computed travel times ranged from a minimum of 0.7 years between MW-2 and the river to a maximum of 4.1 years between MW-6 and the river.

1.2.4 NATURE AND EXTENT OF CONTAMINATION

1.2.4.1 <u>Previous Investigations</u>

1.2.4.1.1 Pre-RI Investigations

Thirteen previous investigations that pertain to environmental conditions at MTL were completed between September 1968 and December 1987. Reports of these

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Table 1-5

Travel Time Summary

Well	Change in Elevation (ft)	Flow Distance (ft)	Hydraulic Gradient	Flow Velocity[a] (ft/day)	Travel Time[b] (days)	Travel Time[b] (years)	Comments
MW-1	16.2	480	0.0338	1.33	362	1.0	See Flow Path T1, Figure 1-13
MW-2	12.3	270	0.0456	1.79	268	0.7	See Flow Path T2, Figure 1-13
MW-5	4.3	270	0.0159	0.63	766	2.1	See Flow Path T5, Figure 1-13
MW-6	2.3	285	0.0081	0.32	1512	4.1	See Flow Path T7, Figure 1-13
MW-11	3.8	420	0.0090	0.36	1349	3.7	See Flow Path T6, Figure 1-13
MW-17	10.3	270	0.0381	1.50	320	0.9	See Flow Path T3, Figure 1-13
MW-18	3.7	270	0.0137	0.54	891	2.4	See Flow Path T4, Figure 1-13

[a]Flow velocity computed as a function of hydraulic gradient, hydraulic conductivity, and soil porosity using Darcy's Law, where:

> Hydraulic conductivity (11.8 ft/day) was computed as the average (geometric mean) hydraulic conductivity from MW-1, MW-2, MW-5, MW-6, MW-11, and MW-17.
>
> Soil porosity is assumed to be equal to 0.3.

[b]Travel times computed between shallow monitor wells and the Charles River as ratio of flow distance to flow velocity.

investigations, which antedate RI/FS investigations, are listed in chronological order below:

- Environmental Radiological Monitoring Plan for the Army Materials Research Reactor, Charles E. Dady and Leo F. Foley, 13 September 1968.

- Plating Wastewater Pretreatment System, Alonzo B. Reed, Inc. and Hoyle, Tanner & Associates, Inc., September 1978.

- Wastewater Engineering Survey No. 32-61-0134-79, Department of the Army, U.S. Environmental Hygiene Agency, North Regional Division, May 1979.

- Investigation of Storm Drain Pollutants at MTL, Coffin and Richardson, Inc., July 1979.

- Installation Assessment of United States AMMRC, Report No. 169, U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), April 1980.

- Environmental Assessment Report for Phase 1 of the AMMRC Master Plan, Camp, Dresser & McKee, Inc., May 1980.

- Air Pollution Status and Environmental Survey No. 44-21-0214-81, U.S. Army Environmental Hygiene Agency, January 1981.

- Investigation of Storm Drain Pollutants, Coffin and Richardson, Inc., July 1979, revised January 1982.

- Radiological Safety Survey, Nuclear Reactor, John F. Vining III, Acting An. Safety Officer (Internal Army Report), June 1982.

- Radiological Survey of the Former Watertown Arsenal Property, GSA Site, Argonne National Laboratory (ANL), October 1983.

- Environmental Compliance Audit - MTL, PRC Engineering for U.S. Army Engineer Division, May 1986.

- Geotechnical Report, Army Materials Technology Laboratory, Watertown, Massachusetts, GZA, December 1987.

- PA/SI for the U.S. Army Materials Technology Laboratory, EG&G Idaho, Inc., March 1988.

A summary of findings of the reports available to WESTON is included in Table 1-6.

In 1987, THAMA initiated additional environmental investigations under the Army's Installation Restoration Program (IRP). A PA/SI (EG&G, 1988) was performed as the

Table 1-6

Summary of Findings of Previous Investigations at MTL

Investigation Citation	Findings
Dady and Foley, September 1968	Liquid wastes generated by the reactor were collected in a 440-gallon sump located in the reactor basement. The liquid was then transferred into three 3,000-gallon tanks located in Building 97 and a 40,000-gallon UST for storage and possible treatment. Prior to discharge into the Metropolitan District Commission (MDC) sanitary sewer system, the liquid was sampled by reactor personnel to determine compliance with radiation concentration levels (10 CFR 20 Appendix B). (Note: the Dady and Foley report was an environmental radiological monitoring work plan. No conclusions, except for past operational history, can be obtained.)
Tanner and Associates, September 1978	Treatment facilities for Building 312 for removal of hexavalent chromium from rinse wastewaters were seldom used since their installation. Samples were collected from the effluent of the wastewater treatment facilities during normal operations. These samples indicate either concentrated plating solution had been discharged or treatment of wastewater was ineffective. These samples also indicated that discharged rinsewater exceeded state and federal levels for hexavalent chromium and cadmium. MDC sewer user regulations prohibit the discharge of concentrated plating solutions, treated or not.
Coffin and Richardson, Inc., July 1979	Wet weather flow for some storm sewer water exceeded limits for oil, grease, Cu, and Zn. Floor drains in Buildings 37 and 311 and parking lots could have contributed to oil and grease contamination. Elevated Cu levels may be attributed to copper downspouts and roof flashings on various MTL buildings. Elevated Zn levels may be attributed to the reaction of acidic rainwater and various on-site metal objects. Elevated Hg levels were noted but were not attributed to a particular source.
Camp, Dresser & McKee, Inc., May 1980	Evidence of dumping from the mid-1800s was found at the east end of the excessed Arsenal property. Potable water, historically, was supplied by a cistern located under Building 313. One known well, located southwest of Building 60, which tapped a sand and gravel aquifer, was permanently capped in 1969. No air problems were identified; however, two areas should be investigated further: compliance with 1) particulate emission standards for upgraded burners in Building 60, and 2) vapor loss regulations for the gasoline storage tanks should be confirmed. The storage areas for nonradioactive hazardous wastes and radioactive/beryllium wastes should be secured and have roofs installed to protect the barrels. Chemical storage violations occurred and were noted. Greatest potential health hazard was the syntron vibrating polishing facility. Dry weather storm sewer flows should be monitored to determine if AMMRC is contributing to the flow.

Table 1-6

Summary of Findings of Previous Investigations at MTL (Continued)

Investigation Citation	Findings
USATHAMA, April 1980	Review of records identified depleted uranium, beryllium, heavy metals, and organic reagents as major potential contaminants. Portions of MTL have been used as landfills as late as the mid-1800s. An ash burial pit existed prior to the 1930s near Building 60. Argon-41 released from the reactor did not exceed existing Atomic Energy Commission levels. Wastewater discharged into the sanitary sewer system included boiler blowdown containing low concentrations of caustic soda, phosphate, tannin, and pretreated (neutralized, dilution) photographic solutions. Stormwater runoff samples showed higher than expected level of copper, mercury, zinc, grease, and oil during wet weather flow. The cistern underneath Building 313 appeared to have had pipes leading into the system. Origination of the pipes is unknown.
U.S. Army Environmental Hygiene Agency, January 1981	All air emission sources investigated were found to be in compliance with federal and state air pollution emission standards. Sampling locations included the following (Building, Description): 312, Beryllium Process; 312, Depleted Uranium; 312, Metal Plating Shop; 39, Dynamic Corrosion Test Area; 39, Acid Scrubber (on roof); 37, Vehicle Maintenance Shop; 43, Depleted Uranium Incinerator; 43, Electric Arc Furnace; 60, Main Boiler Plant; 60, Petroleum Tank Farm. Procedural inadequacies that existed include late submission of state emission registration forms and requirements for source emission testing of the main boiler plant (Building 60).

first step of this program. The PA/SI scope of work included an assessment of previous uses of the 15 existing on-site buildings and 15 existing structures, several buildings/ structures that had been razed prior to the PA/SI, and also potential contaminants associated with the previous uses of the buildings/structures.

A more comprehensive list of chemicals used and stored at MTL is presented in Appendix L of the Phase 2 RI Report (WESTON, May 1994). The appendix provides a listing of chemical usage in the metallurgy lab in Building 39, a chemical inventory for MTL buildings, and the hazardous waste disposal records of MTL for 1990 and 1991.

The PA/SI subdivides MTL into 18 geographical units, each of which contains a mixed assemblage of potential waste sources (Figure 1-3). The 18 units are laid out in such a way that each contains a separate building or structure or group of structures (if the structures are small or have similar missions). The assessment of previous practices and uses of the on-site buildings and their associated contaminants are presented as a separate discussion for each of the 18 geographical units. The PA/SI also includes a soil gas investigation to preliminarily characterize source areas.

1.2.4.1.2 Phase 1 RI

Based upon the findings of the PA/SI, a technical plan was prepared for a Phase 1 RI (EG&G, May 1988). The Phase 1 RI had four objectives:

- Determine the historical and present uses of the laboratory facilities.
- Identify and quantify the contaminants and their locations at MTL.
- Determine the sources of the contamination and the potential for environmental impacts from past and present operations.
- Address the actions necessary to prevent negative future environmental impacts.

The primary motive for selecting the type and quantity of data collected for the Phase 1 RI was the need to describe the nature and extent of contamination at MTL. The sampling and analyses were designed to characterize the hydrogeologic conditions beneath MTL and to define the spatial distribution of any contaminants that may be present (EG&G, May 1988).

A secondary objective of the Phase 1 RI sampling program was to acquire sufficient data for the development of a preliminary risk analysis for the MTL site.

The third objective of the program was to use the data collected in the preparation of an FS for the site. The data collected during Phase 1 was used in conjunction with Phase 2 data for the development and evaluation of remedial alternatives.

The primary target areas of the Phase 1 RI sampling effort were the subsurface soils, the groundwater, and the storm sewer/outfall system at MTL. The intent of the Phase 1 sampling was to screen the site for possible subsurface sources of contamination as well as to define possible subsurface contaminant pathways. It was also intended to determine preliminarily whether or not water and sediment flow in the MTL storm sewer system could serve as a transport mechanism for contaminant migration to the Charles River.

The other target areas included facility buildings, utilities (polychlorinated biphenyl [PCB] transformers), and storage tanks. For these areas, the Phase 1 sampling program was designed to determine whether each area contains the types and quantities of contaminants that would present risks to human health (through direct exposure) or the environment.

In 1988, a field sampling program based on the technical plan (EG&G, 1988) was conducted by EG&G. As part of field activities, various air, dust, sediment, surface water, wipe, and surface and subsurface soil samples were collected and analyzed for various contaminants (volatile organic compounds [VOCs], base/neutral/acid extractable organic compounds [BNAs], pesticides, metals, and radiological parameters). Results of these field efforts are presented in the "Environmental Investigation Status Report" (EG&G, 1990).

Because of the development of various issues surrounding the laboratory that analyzed these samples, the results of this program were considered insupportable by AEC. Consequently, ADL was retained by EG&G to perform resampling in 1990, concurrent with the preparation of the Status Report (EG&G, September 1990). This effort was intended to repeat the original RI sampling performed in 1988; however, not all samples were repeated, and some samples were added to the 1990 sampling effort as well. Results of this field effort are presented in a report (ADL, 1990).

Results of the Phase 1 sampling effort, as well as conclusions and a preliminary risk assessment, are presented in the Phase 1 RI (WESTON, 1991). The Phase 1 RI Report was prepared primarily using the information collected during the resampling event that occurred in February 1990 (ADL, 1990). In instances where a particular sampling point or a particular sampling medium (such as air or dust) was not resampled in 1990, the 1988 results (EG&G, 1990) were used.

1.2.4.2 Scope of the Phase 2 RI

1.2.4.2.1 Potential Hazards Addressed in the RI/FS

As part of contract DAAA15-90-D-0009, WESTON has been tasked to perform a Phase 2 RI at MTL. The Phase 2 Statement of Work (SOW) issued by AEC on 29 August 1990 directed WESTON to complete the following tasks:

- Develop approved technical plans as identified by Section C.3.2.1.1.1 of the basic contract and Section 5.2 of the SOW.

- Conduct a field program implementing these plans to (a) ultimately meet the program requirements of AR405-90 and the Army's goal of property transfer, and (b) fulfill all data gaps and needs identified by the Phase 1 RI.

The Phase 2 scope of field activities is presented below:

- Storm/sanitary sewer investigation
- Inspection and survey of containers
- Geophysical investigations
- Surface and subsurface soils investigations
- Groundwater investigations
- Surface water and sediment investigations
- Radiological investigations
- Building interior wipe sampling investigations
- Air investigation
- Status report of MTL's radon program
- Removability test
- Mixed waste investigation

1.2.4.3 Findings of the Phase 2 RI

In overview, the Phase 2 RI Report indicated that of the many media sampled during the RI, only soils and select building interiors will require remediation. Remediation of any potential hazards posed by radon, asbestos, USTs, and PCB transformer oils is not part of the RI/FS scope. Instead, MTL and the Army will continue to manage these potential hazards with ongoing programs.

Findings of the Phase 2 RI investigations are summarized below. Detailed discussions of the findings of the RI, as well as data tables and data interpretation are presented in the RI report (WESTON, May 1994).

1.2.4.3.1 Geophysical Investigation

A geophysical investigation using ground-penetrating radar (GPR) and/or an electromagneto-meter was performed over portions of the site to assist in locating the following:

- Suspected USTs
- Fill areas
- Sewer line junctions

Since geophysical methods are not exact, they were used in conjunction with site sampling results to draw conclusions about the areas investigated.

The parking lot between Buildings 37 and 131 was surveyed for the presence of a UST. Elevated readings, perhaps indicating buried metal, were detected in the northern end

of the lot. During the Phase 2 RI, it was speculated that this area was likely a UST, since aerial photographs show what appears to be a gas pump located approximately 100 ft southwest of this disturbed area, and since a monitor well downslope of the area contained some VOCs associated with fuel products. A recently discovered "As Built" plan for the area, entitled AMMRC Relocation, Site Modification, Demolition Plan No. 2 (drawing no. 16-06-13, sheet no. 9, 1968), contains text in the area of the UST that reads "remove fuel pumps and associated piping." Since publication of the RI report (WESTON, May 1994), the Army Corps of Engineers- New England Division (CENED) indicated that the location of the UST was beneath the former gas pump; not 100 feet to the northeast, as was originally thought. Based on these indications, an extensive test pit investigation was conducted by the Army in September 1994. Based on this investigation, it has been determined that there currently is no UST in this area, indicating that it was removed at some point in the past, probably at the same time that the pumps and piping were removed.

The park along the Charles River, the on-site area north of North Beacon Street, and the areas south and west of Building 60 were surveyed for the presence of fill. More than half of the park area (primarily in the western portion) consists of disturbed soil or fill. Measurements suggesting buried metal were recorded in the northwestern and northeastern corners of the surveyed area of the park and in a small area in the center of the park. Areas north of North Beacon Street also contained disturbed soil or fill. High conductivity readings were detected near the propellant storage area and near the steep bank to the north of the propellant storage, suggesting the presence of buried metals. Three disturbed areas were located near Building 60. The hillside and flat area southwest of the building appear to be all fill, and slag was observed on the hillside. Since publication of the RI, CENED has performed test pits in the areas of the GPR anomalies. The results of the test pits showed no buried features of concern.

Visual inspection and GPR were used to revise the understanding of the piping configuration at five sewer junctions where discrepancies existed between site sewer maps and diagrams by ADL from the Phase 1 RI. Based on the current understanding of existing site maps, the ADL diagrams, and Phase 2 data, some of the representations of sewer junctions on existing facility blueprints are incorrect.

1.2.4.3.2 Soil Investigation

Sampling Program — A soil sampling program was carried out to identify and delineate potential soil contamination throughout the facility. A facility-wide grid system (sampling on 300-ft centers) not biased toward areas of suspected contamination was used to collect data throughout the MTL property. Additional borings were installed in areas where contamination had been identified in previous studies or near locations where hazardous or radioactive constituents may have been stored or used. Subsections 2.3, 2.5, and 4.3 of the Phase 2 RI report discuss the details of the soil investigation. Figures 1-17 and 1-18 depict the sampling locations.

During Phase 2 sampling activities, 62 soil borings were advanced from ground surface to the water table using a continuous split-spoon sampling technique. In addition, 30

surface soil samples were collected using stainless steel bowls and scoops. Approximately 180 soil samples were submitted for laboratory analysis for volatiles; semivolatiles; cyanide; metals; pesticides/PCBs; radiological parameters, including gross alpha and beta; and uranium isotopes U-234, U-235, and U-238. In addition, selected soil samples collected from 18 of the soil borings were analyzed for total organic carbon (TOC). Additional soil samples were collected from beneath the floor of Building 43 in conjunction with a concrete coring program to investigate contaminant profiles beneath the concrete floor. Surface soil samples were collected from a total of 11 locations beneath the floor. Results of this sampling are detailed in the Addendum to the Phase 2 RI Report (WESTON, January 1993).

Soil Sampling Results — Soil samples collected from beneath concrete floors in Buildings 43, 311, and 312 showed elevated concentrations of semivolatile organic compounds (SVOCs). Contaminant concentrations were generally highest at ground surface. SVOCs detected include (numbers in parentheses represent the maximum concentration detected):

- Beneath Building 43 — 2-methylnaphthalene (7.7 μg/g), anthracene (μg/g), benzo [g,h] perylene (13.6 μg/g), benzo [k] fluorathene (14.6 μg/g), fluoranthene (greater than 6.2 μg/g), dibenzo [a,h] anthracene (2.72 μg/g), fluorene (1.25 μg/g), and bis [2-ethylhexyl] phthalate (4.28 μg/g).

- Beneath Building 311 — benzo [b] fluoranthene (0.612 μg/g), and benzo [k] fluoranthene (1.18 μg/g).

- Beneath Building 312 — 2-methylnaphthalene (71.6 μg/g), benzo [a] anthracene (388 μg/g), benzo [a]pyrene (>124 μg/g), benzo [b] fluoranthene (299 μg/g), benzo [k] fluoranthene (292 μg/g), indeno [1,2,3-c,d] pyrene (236 μg/g), chrysene (283 μg/g), and dibenzo [a,h] anthracene (46.7 μg/g).

Elevated concentrations of polynuclear aromatic hydrocarbons (PAHs) (a subgroup of semivolatiles typically found in petroleum distillate products or other petroleum-related products such as coal tar or asphalt) were detected in soil samples collected from borings completed in the grassy area between North Beacon Street and the Charles River. PAHs detected include (numbers in parentheses represent maximum detected concentration in this area):

- Benzo [a] anthracene (5.93 μg/g), benzo [b] fluoranthene (4.88 μg/g), and benzo [k] fluoranthene (6.17 μg/g) in 17SB-2, 17SB-3, GRSB-22, and GRSB-23. (Maximum values all detected in the surface sample from 17SB-2).

- Benzo [a] pyrene (8.41 μg/g) in 17SB-2 and 17SB-3. (Maximum value detected in the surface sample from 17SB-2).

- Chrysene (4.61 $\mu g/g$) in 17SB-2, 17SB-3, GRSB-22, and GRSB-23. (Maximum value detected in the surface sample from 17SB-2).

- Indeno [1,2,3-c,d]pyrene (8.22 $\mu g/g$) in 17SB-2 and 17SB-3. (Maximum value detected in the surface sample from 17SB-2).

The highest levels of PAHs at MTL were detected adjacent to Buildings 39 and 227/60, and in the parking lot between Buildings 37 and 131. Specific PAHs detected include (numbers in parentheses represent maximum detected concentration in this area):

- Adjacent to Building 39 (05SS-01/-02) — benzo [a] anthracene (11.8 $\mu g/g$ at 0.2 ft bgs), benzo[a]pyrene (10.7 $\mu g/g$ at 0.2 ft bgs), benzo [b] fluoranthene (11.6 $\mu g/g$ at 0.2 ft bgs), benzo[k] fluoranthene (8.58 $\mu g/g$ at 0.2 ft bgs), chrysene (4.69 $\mu g/g$ at 0.2 ft bgs), dibenzo [a,h] anthracene (1.65 $\mu g/g$ at 0.2 ft bgs), and indeno [1,2,3-c,d] pyrene (14.3 $\mu g/g$ at 0.2 ft bgs).

- Adjacent to Building 227/60 (12SB-2) — benzo [a] anthracene (4.55 $\mu g/g$ at 8 ft bgs), benzo [a] pyrene (3.35 $\mu g/g$ at 8 ft bgs), benzo [b] fluoranthene (3.92 $\mu g/g$ at 8 ft bgs), benzo[k] fluoranthene (3.57 $\mu g/g$ at 8 ft bgs), chrysene (3.97 $\mu g/g$ at 8 ft bgs), dibenzo[a,h] anthracene (0.84 $\mu g/g$ at 8 ft bgs), and indeno [1,2,3-c,d] pyrene (7.16 $\mu g/g$ at 8 ft bgs).

- Parking Lot Between Buildings 37 and 131 (GRSB-15) — benzo [a] anthracene (7.69 $\mu g/g$ at the surface), benzo [a] pyrene (8.23 $\mu g/g$ at the surface), benzo [b] fluoranthene (8.13 $\mu g/g$ at the surface), benzo [k] fluoranthene (6.08 $\mu g/g$ at the surface), chrysene (7.11 $\mu g/g$), dibenz [a,h] anthracene ($\mu g/g$), and indeno [1,2,3-c,d] pyrene (11.1 $\mu g/g$ at the surface).

Analytical results showed that the total uranium activity in all soil samples was below the federally mandated maximum allowable total activity for DU of 35 pCi/g for soil (46FR 52061).

Detectable concentrations of metals, primarily beryllium, were reported in shallow (less than 1 ft) soil samples collected from immediately outside Buildings 39, 43, 311, 313, and Structure 656. Detected beryllium concentrations were (numbers in parentheses represent maximum detected concentration in this area):

- 1.09 $\mu g/g$ (12 ft bgs) outside Building 39.
- 0.792 $\mu g/g$ (22 ft bgs) outside Building 43.
- 1.96 $\mu g/g$ (14 ft bgs) outside Building 311.
- 0.792 $\mu g/g$ (22 ft bgs) outside Building 313.
- 1.06 $\mu g/g$ (10 ft bgs) outside Structure 656.

Pesticides were detected in surface soil samples, particularly in the grassy areas within the southeast and central portions of the site and along the southern fence line.

Pesticides detected include (concentrations in parentheses represent maximum detected concentration in a given sampling unit):

- Chlordane (9.36 μg/g in s-2), dieldrin (0.057 in the surface sample of GRSB-21), heptachlor epoxide (0.12 μg/g in s-5), DAD (3.48 μg/g in 13SS-2), DDE (5.94 μg/g in 13SS-2), endrin (>0.5 μg/g in the surface sample of GRSB-21), and PCB 1260 (4.87 μg/g in 13SS-5) in the central portion (Unit 13) of the installation.

- Chlordane (1.7 μg/g in 14SS-1) and dieldrin (0.31 μg/g in 14SS-1) in Unit 14.

- Dieldrin (0.075 μg/g in the surface sample of 15SB-2) and DDT (5.2 μg/g in the surface sample of 15SB-2) in Unit 15.

- Chlordane (3.5 μg/g in 16SS-2) and heptachlor epoxide (0.1 μg/g in 16SS-2) in Unit 16.

- Chlordane (3.09 μg/g in 06SS-4), dieldrin (0.044 μg/g in 06SS-4), and heptachlor epoxide (0.087 μg/g in 06SS-4) in Unit 6.

Concurrent with Phase 2 sampling activities, approximately 177 tons of soil contaminated by a leak of No. 6 fuel oil on the north side of Building 227 were excavated to a depth of 14 ft by a contractor to MTL. When the excavation threatened the structural integrity of Building 227, the excavation was discontinued. Results of samples taken from the excavation piles indicated the presence of fuel-related compounds. Clean soil was used to backfill the excavation. Follow-on investigations in the area of the leak by ABB-ES (ABB-ES, December 1994) found that petroleum hydrocarbon contamination exists in discrete layers in subsurface soils to the south, east, and west of Building 60/Structure 227. TPH concentrations in excess of 20,000 to 50,000 mg/kg were found in borings drilled in these areas, and it appears that the lateral extent of the contamination in the southerly, easterly, and westerly directions has not been fully characterized. The study also concluded that the petroleum contamination in these areas was fuel-oil rather than gasoline-related, based on limited presence of BTEX compounds in area soils.

It should be noted that the investigations described in the ABB-ES report were performed under the requirements of the MCP (310 CMR 40). Post-RI studies at the Building 60/227 and well C-2 sites fall only under the regulatory authority of MADEP as specified in the MCP. This shift in regulatory primacy for these two sites at the installation is the result of suspected petroleum releases discovered during Phase 2 field activities. Petroleum is the only contaminant of concern at these sites; CERCLA has no specific provisions governing petroleum releases to soil or groundwater. Remedial actions at these two sites are to be conducted separately from actions conducted under the NCP at the remainder of the sites on the installation. Hence, contamination from this area has not been included in the human health risk assessment.

Human Health Risk Assessment for Exposure to Soils — In 1989, the town established the Arsenal Reuse Committee to develop a reuse plan for the MTL property for consideration by the Watertown Council. The Plan, entitled the "Reuse Planning and Feasibility Study", was produced in November 1993, by Goody, Clancy, and Associates. The Plan serves as an ongoing liaison between the Army and all other federal and state agencies concerning the closure of MTL and the subsequent cleanup. While partially funded by the Department of Defense, the Plan is a product of the Reuse Committee. Four major reuse zones were identified in the Plan as the containing the most likely future reuses of the site. These zones, with the addition of the grassy area along the river, were used to evaluate potential future exposures in the Human Health Risk Assessment.

The Human Health Risk Assessment used background concentrations based on sampling results from upgradient soil samples to assist in determining site-related compounds. Background samples are those samples located in such a way as to be uninfluenced by site activities. As such, these samples do not have to be off-site, but merely located away from and/or upslope or upgradient of site operations. In addition, background samples need not be pristine, just outside of site influence. Upgradient samples for groundwater are located based on groundwater flow direction. For a sample location to be considered upgradient of a site, groundwater must flow from the sample location toward the site.

For soil, the following potential exposure pathways and exposure routes were evaluated:

- Future child and adult site residents — ingestion of and dermal contact with yard soil and soil in the park areas. Ingestion of vegetables grown in contaminated soil was also evaluated. Exposure to excavated soil (0 to 12 ft deep) was considered where appropriate.

- Future commercial office workers — soil ingestion.

- Future construction workers — soil ingestion and soil dust inhalation.

The carcinogenic risk range within which EPA regulates risk management decisions at hazardous waste sites is 1E-06 to 1E-04. Generally, the upper limit of this range (1E-04 for cumulative site risk) represents the threshold criterion, above which EPA considers remediation to be required. MADEP considers the total site risk from exposure to carcinogens in excess of 1 in 100,000 as unacceptable. The RI and previous versions of this FS were written according to MCP requirements; therefore, a 1 in 100,000 (1E-05) cancer risk has been used as the action level for remediation.

Potential carcinogenic risks for future resident adults and children as a result of soil exposure in each of the four zones exceeded 1 in 100,000. Where gardening was considered as part of the future residential use (Zones 1 and 4), exposure through consumption of vegetables was the most significant exposure pathway, with risks exceeding 1 in 10,000. If Zone 4 were not further developed as a residential area and deeper soils (below 2 ft) were not excavated and spread on the surface, potential risks

were calculated to be less than 1 in 100,000. Potential carcinogenic risks in Zones 2 and 3 exceeded 1 in 100,000, primarily as a result of the potential ingestion of soil.

Potential exposures to soils for future commercial workers would produce estimated risks in excess of 1 in 100,000 for exposure to Zone 2 or Zone 3 soils, but not for Zone 1. Construction worker scenarios produced estimated risks of less than 1 in 100,000.

Analytical results showed very little evidence of radioactive isotope concentrations above background. Risk assessment results did not indicate any health risks in excess of 1 in 100,000 as a result of the presence of radioactive isotopes.

For noncarcinogenic risks, EPA considers a hazard index (HI) (sum of the ratios between the assumed daily intake of a substance and the maximum daily dose that could be incurred without deleterious health effects for all substances considered) of 1 or less to be unlikely to cause any adverse health effects. Metals concentrations were reported above background in shallow (less than 1 ft) soil samples collected from immediately outside Buildings 39, 43, 311, 313, and 656. Risk assessment results indicated that elevated metals concentrations in soil do not pose a significant noncarcinogenic risk to humans (HI less than 1).

Noncarcinogenic pesticides were detected in surface soil samples, particularly in the grassy areas within Units 13, 14, 15, and 16. Noncarcinogenic HI values slightly exceeded 1 under potential residential exposure to excavated (surface and deep) soil in Zone 4 (HI = 2). This HI was primarily the result of ingestion of vegetables potentially grown in contaminated soil. All other zones and scenarios produced estimated HIs of less than 1.

To assess site lead concentrations, the Integrated Exposure Uptake Biokinetic Model (IEUBK) was used to predict acceptable blood levels for future residents (EPA/540/R-93/081). This model, along with the Baseline Risk Assessment, concluded that lead was not a sitewide contaminant of concern, but isolated lead "hot spots" may have a localized risk. The IEUBK model is used to assess childhood exposures to lead in all media. At present, for nonresidential adult exposures, EPA Region I defaults to a 500 mg/kg to 1,000 mg/kg soil lead range. Adult exposures are assessed qualitatively by comparing average soil concentrations to this range. Soil concentrations below the 500 to 1,000 mg/kg soil lead range are unlikely to pose adverse health effects to adults. A number of adult lead models are available, but none have been endorsed by the EPA. Using the EPA default levels for lead in soil, four sample points had lead levels in excess of 1,000 mg/kg. These samples are 02SS-2 (1,120 mg/kg), 03SS-2 (1,530 mg/kg), 05SB-2 (7,160 mg/kg), and GRSB-11 (1,330 mg/kg). In addition to these samples, three other samples had lead levels between 500 and 1,000 mg/kg; these samples are 09SS-2 (792 mg/kg), 11SB-2 (857 mg/kg), and 12SB-2 (763 mg/kg). All other soil samples had lead levels below 500 mg/kg.

The carcinogenic and non-carcinogenic human health risks from potential exposures to MTL soil were used in conjunction with calculated potential risks to potential ecological receptors for the calculation of chemical-specific cleanup goals for soil in Zones 1, 2, 3, 4, and the river park. The potential ecological risks are discussed in the paragraphs that follow. Chemical-specific soil cleanup goals are derived in Section 2.

Terrestrial Ecological Risk Assessment — As part of Phase 2 RI evaluations of the MTL facility, an assessment of risks to ecological populations at the installation was conducted. The results of this assessment are presented in a report entitled "Baseline Risk Assessment- Environmental Evaluation" (Life Systems, Inc., December 1993). As part of the ecological assessment it was determined that terrestrial populations and communities in the area of the installation were not of ecological concern. For this reason, the only exposure endpoints evaluated were fish inhabiting the Charles River, and migratory birds visiting the river on a transient basis.

Since the transfer of regulatory authority from MADEP to Region I EPA, the issue of risks posed to terrestrial populations at the facility has been revisited, and a Terrestrial Ecological Risk Assessment has been produced that complies with the substantive requirements of CERCLA (WESTON, 1995). This evaluation characterized risk to terrestrial wildlife, terrestrial vegetation, and soil invertebrates posed by MTL soil contaminants. Most of the MTL site has limited potential as ecological habitat. Suitable habitat for terrestrial vegetation and wildlife is restricted to the southeastern corner of the site. This area of the site includes the River Park and the Commander's Quarters; this area was the focus of the terrestrial ecological risk assessment. The terrestrial species evaluated and their relevant exposure pathways are as follows:

- Short-tailed shrew
  - Ingestion of soil invertebrates (i.e., earthworms).
  - Incidental ingestion of soil.
- White-footed mouse
  - Ingestion of vegetation (i.e., seeds).
  - Incidental ingestion of soil.
- American robin
  - Ingestion of soil invertebrates (i.e., earthworms).
  - Incidental ingestion of soil.
- Song sparrow
  - Ingestion of vegetation (i.e., seeds).
  - Incidental ingestion of soil.

- Terrestrial plants

  - Direct contact with soil.
  - Absorption/concentration from soil.

- Soil invertebrates

  - Direct contact with soil.
  - Absorption/concentration from soil.

The potential risk posed to ecological receptors (shrew, mouse, robin, sparrow) was assessed by comparing estimated daily doses to reference toxicity values (RTVs) . This comparison, described as a hazard quotient (HQ) was calculated for each contaminant by dividing the estimated daily dose by the RTV. HQs were summed across all exposure pathways for each contaminant, by receptor, to develop chemical-specific HIs. HQs and HIs were not calculated for plants and soil invertebrates. Instead, available toxicity data were presented and compared directly to soil chemical data.

The HIs for all ecological receptors are presented in Section 5 of the Terrestrial Ecological Risk Assessment (WESTON, June 1995). The HQs and HIs for ecological receptors were calculated using two exposure concentrations: the mean and the 95% Upper Confidence Limit (UCL) of the mean. The following paragraphs provide an overview of the findings of the ecological risk assessment and highlight contaminants that contributed substantially to the total hazard for each receptor:

- Northern short-tailed shrew. Based on the mean soil exposure concentrations, chemical-specific HIs that exceeded 10 included chlordane (12), chromium (22), nickel (360), and zinc (13). Based on the 95% UCL exposure concentrations, chlordane (41), DDT (46), arsenic (13), chromium (24), lead (37), nickel (430), and zinc (15) result in exceedances of an HI of 10. Approximately 87-93% of the HIs can be attributed to the earthworm ingestion exposure route.

- White-footed mouse. Nickel was the only contaminant that exceeded an HI of 10 for the mouse. The HIs calculated for nickel were 16 and 19, based on the mean and the 95% UCL exposure concentrations, respectively. Seed ingestion contributed the majority of the risk (>70%).

- American robin. The exposure route that contributed the most risk to the robin was the earthworm ingestion route (> 95%). Within this pathway, pesticides contributed the largest portion of the risk (86% for mean exposure concentrations ; 96% for the UCL). Based on the mean soil exposure concentrations, HIs that exceeded 10 include DDE (40) and DDT (48). Based on the 95% UCL exposure concentrations, HIs that exceeded 10 include DDE (180), DDT (280), and endrin (16).

- Song sparrow. No chemical-specific HIs exceeded 10 for the song sparrow. Only two HIs exceeded one (DDT-2.2, endrin-1.9), based on the 95% UCL exposure concentrations.

An HI of less than 1 indicates that adverse effects are not likely to occur, and no action is required. An HI of greater than 10 indicates that risks are at a level of potential concern, and may warrant action, depending upon the nature of the risk, the nature of the site and surrounding properties, evaluations of background levels of contaminants in the area under investigation, and uncertainties associated with the risk calculation. An HI between 1 and 10 is subject to interpretation based on the toxicity of the chemical and the uncertainty in the calculation. In addition, the frequency of detection and reproducibility of the data should be investigated. Whether a remedial action must be initiated should be examined on a site-by-site basis, after careful consideration of the levels of the hazard indices compared to the possible adverse impacts of remedial action on the ecological habitat (e.g., loss of existing wetland communities and other habitats, or increased contaminant migration resulting from resuspension of contaminated fine-grained particles). The only receptors whose exposure to soil contaminants at MTL would result in HIs exceeding 10 are the shrew, the white-footed mouse, and the robin.

A comparison of soil concentrations at the site with phytotoxicity data show the potential for phytotoxic effects to occur at some locations on the site. Exceedances of phytotoxicity data occurred for arsenic, cadmium, copper, lead, and zinc. These metals occurred at concentrations on the site that have been shown to cause yield reductions, growth retardation, leaf discoloration, and reduced germination.

Potential effects to soil invertebrates may also occur at some locations at the site. Exceedances of toxicity data were observed for chlordane, DDE, copper, and zinc. The maximum detected concentrations of copper and zinc at the site exceed LC_{50}s for earthworms, and a number of other locations exceeded an EC_{50} value for cocoon production in earthworms. Chlordane exceeded concentrations at which sperm count depressions have been observed in earthworms, and DDE exceeded concentrations at which epidermal changes have been observed in earthworms.

1.2.4.3.3 Groundwater Investigation

Sampling Program — An investigation was carried out to characterize groundwater upgradient of and beneath the facility. The Phase 2 investigation consisted of installing 15 groundwater monitor wells, while an earlier Phase 1 investigation consisted of installing 16 wells. One groundwater sampling round was completed, and groundwater samples from the 31 wells were submitted to a laboratory for analysis of volatiles, semivolatiles, metals, cyanide, pesticides/PCBs, and radiologic parameters, including gross alpha, beta, and gamma activity and uranium isotopes U-234, U-235, and U-238. Sampling locations and procedures are discussed in Subsections 2.4 and 4.4 of the Phase 2 RI Report. Figures 1-19 and 1-20 depict these locations. Eight wells were selected as upgradient locations. Five of these wells (MW-16, MW-16A, MW-22, MW-23, and MW-24) are located off-site; the other three wells (MW-9, MW-10, and MW-13) are located on the northern property border near Arsenal Street.

No Human Health Risk Assessment was completed for groundwater because groundwater in the vicinity of the site is not used as a water source and will not be used as one in the foreseeable future. Watertown is a MWRA member community and obtains its water supply from several reservoirs in Massachusetts.

In a letter dated December 31, 1994, from MADEP to the U.S. Army Base Closure Division, the groundwater was classified as GW-3 in accordance with Section 40.0006 of the MCP. According to the MCP, a GW-3 groundwater classification means that remediation decisions regarding the aquifer in question need only address potential ecological risks posed by groundwater contaminants. Human health risks need not be considered as they would be for a GW-1 or GW-2 classification. A GW-1 classification accounts for the potential use of the aquifer as a drinking water supply. A GW-2 classification is based on human health risk from exposure to vapors present in building basements caused by VOC-contaminated groundwater. MADEP's rationale for the GW-3 classification was based upon the MCP exclusion for a potentially productive aquifer that is located in a municipality with a population density greater than 4,400 persons per square mile. Watertown meets this exemption and the aquifer beneath the MTL site is not classified as a potentially productive aquifer. Also, VOC-contaminated groundwater is not a concern at the site. Because, according to the MCP definitions, no other GW-1 or GW-2 criteria are met, the groundwater is classified as a GW-3.

Sampling Results — With the exception of one well (MW-09), all upgradient wells showed detectable quantities of chlorinated solvents. Chlorinated solvents (solvents commonly found in industrial degreaser solutions) identified in upgradient wells include tetrachloroethylene (PCE), trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA).

In addition, one upgradient well showed elevated concentrations of gasoline-related volatile organics. Based on site water table maps from 1991 and 1995 data, groundwater flow paths indicate the potential for groundwater to flow away from the site in an area in the northwest part of the site before flowing towards the Charles River. No evidence of on-site contamination migrating off-site in the northwest area of the site was found in groundwater collected from on-site wells. Most likely, a groundwater divide exists under a short stretch of Arsenal Street near the northwestern corner of the site. In general, however, groundwater flows from north of Arsenal Street to the site.

Chlorinated solvents including TCE and PCE were detected in groundwater samples collected from 13 on-site monitor wells. The 13 wells and their detected chlorinated solvents are:

- Western wells-
  MW-01- 1,1-dichloroethane (2.83 μg/l)
  MW-14- PCE (3.61 μg/l)
  MW-15- 1,2-dichloroethylene (5.19 μg/l), PCE (44.4 μg/l), TCE (94 μg/l)
  MW-15A- PCE (40.7 μg/l), TCE (2.9 μg/l)
  MW-17- PCE (1.48 μg/l)

MW-17A- acetone (>100 μg/l), PCE (92.6μg/l), TCE (11 μg/l)
MW-21- 1,1-dichloroethylene (3.35 μg/l), 1,1,1-trichloroethane (3.14 μg/l)

- Central wells- MW-03- PCE (1.67 μg/l)
  MW-08- PCE (12 μg/l), TCE (7.6 μg/l)
  MW-19A- PCE (5 μg/l), TCE (4.4 μg/l)
  MW-19B- PCE (3.43 μg/l), TCE (5.3 μg/l)
  MW-20- PCE (16.7 μg/l), TCE (3.3 μg/l)

- Southeastern wells- MW-11- PCE (1.48 μg/l), TCE (1.5 μg/l)

As shown above, monitor wells located in the western portion of the site reported the highest concentrations of PCE and TCE.

Elevated concentrations of semivolatile 1,3-dimethylbenzene (1,700 μg/l) and volatile xylene (1,390 μg/l) were detected in one well (C-2) located in the central portion of the site. Based on a petroleum odor present during groundwater sampling, contamination is believed to be the result of a fuel oil release. Analytical results from nearby monitor wells suggest the elevated concentrations are restricted to the area around this well.

During completion of a soil boring (10SB-2) beneath the Building 36 parking lot, several inches of free product were observed at the water table. Analysis of a soil sample collected at the water table indicated the contaminant was a fuel oil product. The sample did not contain the more commonly known gasoline-related compounds (benzene, toluene, ethylbenzene, and xylene), but it did contain certain compounds found in some of the heavier fuel oils, such as phenanthrene, fluoranthene, and pyrene. This oil may be No. 6 fuel oil resulting from a pipe release in the area of Building 227; however, the boring in which the free product was found is slightly upgradient of the release, and therefore, the contamination in the central well may be from another source. Groundwater samples collected from downgradient monitor wells did not reveal evidence of the free product, indicating that there has not been contaminant migration in this direction.

It should be noted that the investigations described in the ABB-ES report were performed under the requirements of the MCP (310 CMR 40.0000). Post-RI studies at the Building 60/227 and well C-2 sites fall only under the regulatory authority of MADEP as specified in the MCP. This shift in regulatory primacy for these two sites at the installation is the result of suspected petroleum releases discovered during Phase 2 field activities. Petroleum is the only contaminant of concern at these sites; CERCLA has no specific provisions governing petroleum releases to soil or groundwater. Remedial actions at these two sites are to be conducted separately from actions conducted under the NCP at the remainder of the sites on the installation.

Groundwater Impacts to Surface Water

The initial risk assessment/ecological assessment for the Charles River did not provide an assessment of MTL groundwater impacts to the river. As a result of regulatory FS strategy meetings held at the installation with EPA and MADEP in June and November of 1994, it was determined that, assuming a GW-3 groundwater classification, the only criterion for inclusion of remediation of groundwater contamination is potential contamination of the Charles River via groundwater discharge to the river. In response to this determination, maximum and average contaminant concentrations in those wells along the southern boundary of the installation were compared with available federal Ambient Water Quality Criteria (AWQCs) for protection of aquatic life, assuming chronic, fresh water exposures. Of the 13 contaminants found in southern boundary wells for which AWQCs are available, AWQC exceedances were noted for six metals and one pesticide, assuming no surface water dilution of MTL groundwater at all. As a result of these exceedances, the following three-step analysis was performed:

1) Determine the maximum allowable flow contribution (percentage of total) by MTL groundwater to the river, above which AWQC exceedances could occur.

2) Determine the actual flow contribution (percentage of total) of MTL groundwater to the river, based upon known groundwater and river flow parameters at or near the part of the river adjacent to MTL.

3) Compare the two flow contribution estimates [(1) and (2)] to determine if the contaminant concentrations present in MTL groundwater could result in exceedances of AWQCs. If the percentage determined in (2) exceeds that calculated in (1) for any given contaminant, an AWQC exceedance for that contaminant could occur.

The three steps outlined above are described in more detail in the paragraphs that follow.

In the first step of the analysis, the maximum allowable percentage of MTL groundwater flow contribution to surface water flow in the river was calculated for each contaminant detected in monitoring wells at the southern boundary of MTL. It is at the southern boundary of MTL that discharge to the Charles River occurs. The maximum allowable percent flow contribution is defined as that percent of river flow contributed by MTL groundwater above which an AWQC exceedance could first occur. These were determined by dividing actual AWQC values by contaminant concentrations (both maximum and average concentrations) in those wells for which AWQC exceedances were noted, according to the following equation:

[AWQC (ug/L)]/[Groundwater Contaminant Concentration (ug/L)] X 100 = Maximum Allowable Percent Groundwater Flow Contribution

A table summarizing these results is presented in Appendix B (Table B-1). According to the table, for the maximum concentrations of contaminants in southern boundary wells, the lowest maximum allowable flow contribution of MTL groundwater to the river is 2.19%, based on cadmium as the limiting contaminant of concern.

In the second analysis step, an actual flow contribution (percentage of total flow) by MTL groundwater to the Charles River flow was calculated. This analysis included all hydrogeologic units except the bedrock aquifer. To ensure a conservative analysis of flow contribution, instead of using the entire Charles River as the flowpath, the portion of the Charles River between the island and the MTL shoreline was used as requested by MADEP. This portion of the river channel is where the greatest impacts to surface water are expected. These calculations and supporting assumptions are included as Appendix C. The results of the calculation indicate that if the flow through the northern portion of the River (which runs between the island and the shoreline) is assumed to be 28% of the flow through the entire width of the Charles River (as suggested by MADEP), then the groundwater flowing beneath MTL contributes 1.45% of the total flow to the northern portion of the river along the length of the MTL shoreline.

In the final analysis step, the maximum allowable flow contribution (percent) by MTL to the river (as derived in the first part of the analysis) and the actual flow contribution calculated in the second part of the analysis, were compared. The lowest allowable percent flow contribution from MTL groundwater based on maximum concentrations of contaminants in southern wells was 2.19%, based on cadmium. Since the actual flow contribution has been conservatively estimated at 1.45%, the contribution of contaminants from MTL groundwater would not be expected to result in exceedances of any AWQC values designed to protect ecological receptors in the river.

This analysis did not include the possible flux of the bedrock groundwater aquifer because of the inability to determine a thickness layer of the aquifer that would discharge to the river. To ensure that there would be no potential for AWQC exceedances based on the bedrock groundwater, all contaminant concentrations from the single deep bedrock well (MW-19A) were compared to AWQCs. This comparison showed no exceedances for AWQCs for the protection of aquatic life for either VOCs or pesticides. There was one exceedance of AWQCs for metals: MW-19A exceeded for chromium (40.1 ug/l). However, this AWQC exceedance is not considered significant for the following reasons. First, using the above equation to determine maximum allowable groundwater contribution for AWQC compliance, the maximum allowable percentage of river flow contributed by the bedrock aquifer is 27.4%. Second, using the flow contribution equations presented in Appendix C, a bedrock aquifer thickness layer of at least 308 ft is required to achieve a 27.4% bedrock aquifer contribution to the river. Although the actual bedrock aquifer thickness layer is unknown, it is highly unlikely to have a thickness layer as great as 308 ft discharging to the river. Therefore, even if the bedrock aquifer had been included in the analysis, the conclusions would be the same. This shows that there would be no significant impacts to the river from the deep bedrock groundwater aquifer, as well as from the other layers of the aquifer.

1.2.4.3.4 Storm and Sanitary Sewers Investigation

Sampling Program — The storm sewer investigation consisted of flow monitoring and sampling of storm sewer runoff during a precipitation event, and an internal television (TV) camera inspection to investigate the integrity of the lines and possibility of groundwater infiltration. Background sampling points were used to determine the flow and contaminants contributed from off-site. Subsections 2.7 and 4.6 of the Phase 2 RI Report discuss the storm sewer investigation program in detail. Sample locations are shown in Figure 1-21.

Sanitary sewers were investigated for radiological contamination. Sediment samples were collected from 12 sanitary sewer manholes. DU contamination was present in several manholes. The sampling program is discussed in Subsection 4.7 of the Phase 2 RI Report. Sample locations are shown in Figure 1-22.

Sampling Results — The storm sewers contained little or no sediment; therefore, only liquid samples were obtained during the rain event. Sampling results indicate that the site contributes small amounts of some metals and pesticides to the storm sewer runoff. The only metals that exceeded two times the maximum background values were copper and zinc, both of which also exceeded the typical urban runoff range. Confirmed pesticides concentrations exceeding two times background concentrations were alpha-, beta-, and delta-benzenehexachloride (BHC); chlordane; 1,1-bis-(4-chlorophenyl)-2-chloroethane (DDE); and methoxychlor. No radiological contamination was discovered.

Three storm sewer segments were inspected using TV cameras. The TV inspection revealed that the lines were in good condition with some cracks attributed to natural deterioration. The cracks were found along the joints and sides of pipe constructed of vitrified clay and brick. Although cracks were found, there was no evidence of groundwater infiltration, past or present, in any of the segments investigated.

For the results from the sanitary sewers, uranium was found in a manhole on Arsenal Street connected to the drainlines from Building 43. Since uranium concentrations in two manholes upstream of Building 43 were lower, the contamination in the manhole connected to the drainlines from Building 43 appeared to have been augmented by sources in Building 43.

On North Beacon Street, uranium contamination was found in several manholes. Manhole 120 is the farthest upstream sample taken on the North Beacon Street sanitary line. The source of this contamination is unknown at present. Further sampling of manholes upstream of Manhole 120, as well as tracing (using dye testing or an equivalent method), in order to locate any potential on-site sources of contamination were recommended in the Phase 2 RI; however, this sampling proved to be impracticable, because the next upstream manhole could not be accessed.

Two sanitary sewer line segments were inspected using TV. The sanitary lines are in good condition with some cracks, as in the storm sewer lines. There was no evidence

of past or current groundwater infiltration into the sanitary sewer lines. Because of the apparent integrity of the lines, infiltration of the contamination into the surrounding media is not likely. Sediments in sanitary sewer lines under much of Arsenal Street and North Beacon Street were already removed and drummed to allow a TV camera inspection of the lines. Sediment (including radiologically contaminated sediment) removed from the lines in order to facilitate TV testing was drummed and has been properly disposed of at a licensed facility. Manholes along North Beacon Street, Arsenal Street, exiting Building 312, and exiting Building 43 to Arsenal Street, were remediated as part of the facility radiological remediation. The sanitary sewer along Arsenal Street has been surveyed and found to be free of radiological contamination.

Elevated levels of lead were found in several sewer sediment samples. It cannot be determined whether the source of lead contamination is upstream of MTL or site-related.

Any possible future remedial action deemed necessary for any radioactive contamination remaining in the sanitary sewers would be completed under the NRC delicensing process.

Human Health Risk Assessment from Sewer Exposures - The original Baseline Risk Assessment presented in the RI did not assess risk to individuals working on the sewer lines associated with the site. As a supplement to the original risk assessment, sewer worker exposure was evaluated. This assessment demonstrates that occupational exposures to sediments and water in the sewers can be considered insignificant despite fairly conservative assumptions made during a screening-type analysis.

This analysis addresses dermal and ingestion exposures only. This assessment was not designed to address physical hazards or inhalation risks. Assessing the inhalation risks using data collected from the sanitary sewer sediments is inappropriate because the moist environment inhibits the generation of dust, and because no volatile chemicals of concern were found in the sediment. In addition, OSHA confined-space entry requirements that apply to sewer work would mean that air in the sewer would be flushed prior to entry.

Occupational exposures to the materials in the sewers could occur on an episodic basis. Sewer investigations are not likely to be undertaken routinely. Nonetheless, the analysis that follows assumes that a worker enters the MTL sewer system periodically (six times a year) for inspection or routine maintenance purposes.

When this activity occurs, a conservative assumption would be that the worker is clothed in a work uniform that consists of full-length pants, short-sleeved shirt, and shoes. Both hands and arms could therefore be exposed to either sewer sediments or water. Sewer sediment could be transferred from the hands to the mouth especially after the activity is complete and before soiled clothing is removed. It is unlikely that sewer water would be consumed except during an accidental immersion following a slip or fall. Thus both dermal and oral routes are included in the analysis.

The following oral intake equation was used:

Intake = (C x CR x EF x ED)/(BW x AT x CF)

where:

Intake	= Daily intake of chemicals in sewer water or sewer sediments (L/kg-day or mg/kg-day)
C	= Concentration of contaminant (mg/L or mg/kg)
CR	= Contact rate per sewer event (L/event or mg/event)
EF	= Exposure frequency (events/yr)
ED	= Exposure duration (years)
BW	= Body weight of sewer worker (kg)
AT	= Averaging time (days)
CF	= Conversion factor

The values selected for the exposure point concentrations (C) are from the sampling results reported in the RI (RI Tables 4-41 and 4-43). The upper 95th confidence limit of the arithmetic mean of all hits for each chemical detected in either sewer water or sediments was used (if the confidence limit exceeded the maximum hit, the maximum hit was selected). These values are summarized in Table 1-7.

The values selected for contact rates are highly subjective. The amount of water that could be ingested during each sewer event is assumed to be 50 mL. This is a value frequently used in swimming scenarios, therefore it is highly conservative when used in a sewer activity scenario. The worker is not likely to be underwater for any length of time. There is no readily available information regarding the rate at which sediments might be ingested. In the absence of information, a value of 5 mg per event was used. This represents about 10% of the amount of soil a worker might ingest during a normal workday. Again, this value is highly conservative; it is likely that ingestion of sewer sediments would occur at some lower rate especially since the assumed work space would not be dusty, nor would activities such as eating or smoking be involved.

The assumed exposure frequency is 6 events per year and occurs for 25 years. The 25-year exposure duration is a standard occupational default value. The sewer worker is assumed to weigh 70 kg, which is a standard adult default value. The averaging time is equal to the exposure duration for noncarcinogens and is equal to 70 years for carcinogens.

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Table 1-7

MTL Sewer Hypothetical Exposure Point Concentrations

Chemical	Storm Sewer Water (mg/L)	Sanitary Sewer Sediment (mg/kg)
Acenaphthylene	-	1.3E-01
Aldrin	3.8E-05	-
Alpha-BHC	5.9E-05	-
Alpha-endosulfan	3.9E-05	-
Arsenic	4.7E-03	-
Barium	3.3E-02	1.6E+02
Benzo(a)anthracene	-	1.6E+01
Benzo(b)fluoranthene	-	3.8E+01
Benzo(k)fluoranthene	-	5.9E-01
Beta-BHC	9.7E-06	-
Bis(2-ethylhexyl)phthalate	5.6E-02	6.8E+01
Cadmium (food, soil)	-	6.2E+00
Chlordane	5.1E-04	-
Chromium	-	4.5E+02
Chrysene	-	1.8E+01
Cobalt	-	1.4E+01
Copper	5.8E-01	1.5E+04
Cyanide (free)	8.9E-03	2.8E+00
4,4'-DDD	7.9E-05	-
4,4'-DDE	3.8E-05	-
4,4'-DDT	8.4E-05	-
Delta-BHC	5.0E-05	-
1,4-Dichlorobenzene	-	6.6E+00
Fluoranthene	-	2.6E+01

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Table 1-7

MTL Sewer Hypothetical Exposure Point Concentrations (Continued)

Chemical	Storm Sewer Water (mg/L)	Sanitary Sewer Sediment (mg/kg)
Fluorine	-	1.3E+00
Gamma-BHC (Lindane)	3.6E-05	-
Heptachlor	3.1E-05	-
Manganese (food, soil)	-	3.5E+02
Manganese (water)	1.2E-01	-
Mercury (inorganic)	-	1.5E+01
Methoxychlor	1.3E-04	-
4-Methylphenol	-	6.0E-01
Nickel	-	2.3E+02
Nitrate/Nitrite (nonspecific)	1.1E+00	-
PCB 1260	-	1.1E+00
Phenanthrene	-	2.3E+01
Pyrene	-	3.2E+01
Silver	-	4.2E+01
Vanadium	-	4.5E+01
Zinc and compounds	5.0E-01	1.0E+03

For dermal intakes, the equation was modified slightly as follows:

$$\text{Intake (sediments)} = (C \times SA \times AF \times CF \times EF \times ED \times ABS)/(BW \times AT)$$

$$\text{Intake (water)} = (C \times SA \times P \times ET \times ED \times EF \times CF)/(BW \times AT)$$

where:

SA = Skin surface area exposed (cm^2/event)
AF = Soil adherence factor (mg/cm^2)
CF = Conversion factor (for sediments, kg/mg, and for water, L/cm^3)
ABS = Chemical-specific absorption factor
P = Chemical-specific permeability constant (cm/hr)
ET = Exposure time (hours/event)

All other parameters are the same as for the oral intake equation.

The skin surface area available for exposure is assumed to be 3,120 cm^2 (the average skin surface area of hands and arms for an adult). The adherence factor is assumed to be 0.51 mg/cm^2; this is the value used in quantifying dermal exposure to soils for residents at MTL. The assumed exposure time is 8 hours per event, a standard work shift. The values used for ABS and P are the same as those used for residential populations at MTL.

The calculated intakes were then multiplied by the appropriate slope factors for carcinogenic chemicals and divided by the appropriate Reference Doses for noncarcinogens. Toxicity values were obtained from EPA's Integrated Risk Information System. A toxicity equivalency factor approach was used for the carcinogenic polycyclic aromatic hydrocarbons detected in sewer sediments.

Excess cancer risks were summed by chemical by pathway (ingestion of sewer water and ingestion of sewer sediments). The screening level risk thus estimated is 3E-07, which is below a level of concern. The estimated carcinogenic risk is due primarily to several PAHs detected in the sewer sediments. The Hazard Index calculated by summing the hazard quotients for each pathway is similarly below a level of concern (HI = 1E-02). Table 1-8 summarizes these estimates.

Despite a fairly conservative estimate of exposure, it is unlikely that contact with sewer sediments or water would present a level of concern for a future sewer worker at MTL.

The detailed exposure and risk calculations for the sewer are presented in Appendix D. The format of the calculation tables are identical to those for the Baseline Risk Assessment provided in Appendix P of the RI.

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Table 1-8

Summary of Chemical Risks From Worker Exposure to MTL Sewers

Potentially Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index	Cancer Risk
Sewer Worker	Sewer	Surface Water	Ingestion	1E-03	4E-08
		Sediment	Ingestion	7E-04	2E-08
		Surface Water	Dermal	5E-03	2E-07
		Sediment	Dermal	4E-03	7E-08
			Total:	1E-02	3E-07

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SECTION 2

REMEDIAL ACTION OBJECTIVES

2.1 INTRODUCTION

Prior to the development and evaluation of remedial alternatives, the remedial action objectives for the site must be established. In general, the remedy selected for the MTL site must address the following statutory requirements of the Superfund Amendments and Reauthorization Act of 1986 (SARA):

- The remedy must be protective of human health and the environment.

- The remedy must attain compliance with applicable or relevant and appropriate requirements (ARARs) and federal and state environmental standards, when appropriate, unless a statutory waiver is invoked.

- The remedy must use permanent solutions and alternative treatment technologies to the maximum extent practicable.

Achieving the first two aforementioned statutory requirements involves identification of ARARs and development of site-specific remedial action objectives. EPA policy, as reflected in SARA and in the National Contingency Plan (NCP), requires that the development and evaluation of remedial objectives under Superfund must include a comparison of the protectiveness of site remedial alternatives with federal and state ARARs. Subsection 2.2 presents ARARs that may be applicable to the MTL site.

Remedial Action Objectives

Development of specific objectives involves identification of affected media and contaminant characteristics, evaluation of exposure pathways and contaminant migration, and determination of acceptable exposure limits at the receptor points. The specific media addressed for this FS included soil, groundwater, storm sewers, and sanitary sewers. Based on the summary discussions on field investigation results and risk assessments presented in Section 1, the following conclusions on affected media can be made:

- Certain site soils are of concern and could pose potential risks to human health and the environment.

- Site groundwater is not of concern and does not pose a potential threat to human health or the environment. The groundwater is not a current or future source of drinking water (MADEP has classified the aquifer as GW-3) and groundwater is not used for industrial purposes. Impacts of groundwater on the Charles River have been found to be negligible.

These findings indicate that groundwater remedial action is not necessary at the MTL facility.

- The sanitary and storm sewers on-site do not pose a threat to human health. Risks to worker exposure to the sewer water and sediments have been found to be negligible. There could be potential risk to the environment from discharge of the storm sewers into the Charles River; however, this potential risk pathway is to be assessed as part of the Charles River Operable Unit and is not considered further as part of this FS. For the purposes of this FS, there is no on-site risk posed by the sewers, therefore no remedial action is necessary for the sewers.

The potential cleanup goals developed for outdoor areas of the MTL site were based on a consideration of ARARs (see Subsection 2.2) and results of the site risk assessment.

The general, conceptual-level, remedial action objective for MTL is to:

- Mitigate the risks to human health and the environment posed by direct contact with contaminated soils.

For outdoor areas, the only medium of concern is site soils; therefore remedial action objectives are derived only for this medium.

2.2 ENVIRONMENTAL AND PUBLIC HEALTH ARARS

EPA policy, as reflected in SARA and in the NCP, provides that the development and evaluation of remedial actions under CERCLA must include a comparison of alternative site responses to applicable or relevant and appropriate federal and state environmental and public health requirements.

2.2.1 IDENTIFICATION OF ARARS

Identification of ARARs must be conducted on a site-specific basis. Neither SARA nor the NCP provides across-the-board standards for determining whether a particular remedy will produce an adequate cleanup at a particular site. Rather, the process recognizes that each site will have unique characteristics that must be evaluated and compared to those requirements that apply under the given circumstances. The remedial action selected must meet all ARARs unless a waiver from specific requirements has been granted.

ARARs are defined by CERCLA as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site.

- To Be Considered (TBC) information refers to other federal and state criteria, advisories, guidance, and proposed standards and local ordinances that are not legally binding but that may provide useful information or recommended procedures.

ARARs may be divided into the following categories:

- Chemical-specific requirements are health- or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants.

- Location-specific requirements are restrictions on activities that are based on the characteristics of a site or its immediate environment. An example would be restrictions on wetlands development.

- Action-specific requirements are controls or restrictions on particular types of activities, such as hazardous waste management or wastewater treatment, in related areas. An example would be Resource Conservation and Recovery Act (RCRA) incineration standards.

The chemical-, location-, and action-specific ARARs as well as TBCs for the MTL site are summarized in Table 2-1.

2.2.2 CHEMICAL-SPECIFIC ARARs FOR THE MTL SITE

Chemical-specific requirements "set health- or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants" (52 FR 32496). These requirements generally set protective cleanup levels for the chemicals of concern in the designated media or indicate a safe level of release that may be incorporated into a remedial activity.

With respect to the MTL site, there are no promulgated chemical-specific standards for contaminants in soil. Instead, various methodologies contained in risk guidance were used for calculating risk levels posed by the contaminants to present and future receptors at the site. These risk levels were compared to background levels and soil cleanup goals were then developed. Cleanup goals are derived in Subsection 2.3.

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Table 2-1

ARARs for the MTL Site

- Chemical-Specific ARARs
  - None
- Location-Specific ARARs
  - Resource Conservation and Recovery Act (RCRA) Protection of Floodplains
  - National Historic Preservation Act (NHPA)
  - Archaeological and Historic Preservation Act
  - Commonwealth of Massachusetts Regulations
- Action-Specific ARARs
  - RCRA
  - National Emission Standards for Hazardous Air Pollutants (NESHAPs)
  - Commonwealth of Massachusetts Regulations
- TBC Information
  - EPA Risk Reference Doses
  - EPA Carcinogen Assessment Group Potency Factors
  - EPA Guidance on PCB Remedial Actions at Superfund Sites
  - Federal Test Methods for Evaluating Solid Waste
  - Massachusetts Policy on Allowable Sound Emissions

2.2.3 LOCATION-SPECIFIC ARARs FOR THE MTL SITE

Location-specific requirements "set restrictions on activities depending on the characteristics of a site or its immediate environs" (52 FR 32496). In determining the use of these location-specific ARARs for selection of remedial actions at CERCLA sites, one must investigate the jurisdictional prerequisites of each of the regulations. Basic definitions, exemptions, etc., should be analyzed on a site-specific basis to confirm the correct application of the requirements.

2.2.3.1 RCRA (40 CFR 264.18) and the Protection of Floodplains (40 CFR 6, Appendix A)

Under RCRA, any hazardous waste management facility within a 100-year floodplain must be designed, constructed, operated, and maintained to avoid washout. MTL is located outside of the flood hazard area bordering the Charles River (as shown in Figure 2-1), with the exception of the southern portion of the park area between North Beacon Street and the river, which is within the 100- and 500-year flood zone.

Under the Protection of Floodplains regulations, any work occurring must avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values to the floodplain. All remedial activities will be designed and conducted to ensure that they fall outside the 100-year floodplain.

2.2.3.2 National Historic Preservation Act (NHPA) (16 USC 470 et seq.)

The NHPA is applicable to those properties included in, or eligible for, the National Register of Historic Places. This ARAR requires that action be taken to preserve historic properties. Planning action to minimize the harm to national historic landmarks is required.

The Commander's Quarters on MTL is on the National Register of Historic Places, and the facility itself has been declared a historic district; therefore, the Army will consult with the State Historic Preservation Office to ensure that damage to buildings will be avoided if possible.

2.2.3.3 Archaeological and Historic Preservation Act (16 USC 469A-1)

The Archaeological and Historic Preservation Act provides for the preservation of historical and archaeological data that might otherwise be lost as a result of dam construction or alterations of the terrain. If activities in connection with any federal construction project or federally approved project may cause irreparable loss or destruction to significant scientific, prehistoric, or archaeological data, the Act requires that data recovery and preservation activities be conducted in accordance with

implementing procedures promulgated by the Secretary of the Interior. This Act differs from the NHPA in that it encompasses a broader range of resources than those listed on the National Register and mandates only the preservation of the data (including analysis and publication) (EPA, 1989).

As discussed in Subsection 2.15 of the MTL Phase 2 RI Report, archaeological investigations have established the existence of two known historic sites and one suspected prehistoric site at MTL; therefore, remedial activities involving intrusive work (e.g., excavation, soil borings, and well installation) will require the involvement of archaeologists and state and federal agencies if artifacts are encountered.

An additional Intensive Archaeological Survey was conducted by The Public Archaeology Laboratory, Inc., in September 1995. This survey investigated the three site areas with archaeological vulnerability as identified in Figure 2-2. The survey identified one prehistoric site and one historic site in the Central Investigative Area around the Commander's Quarters. No archaeological resources were detected in the northwest site area or in the River Park.

2.2.3.4 Commonwealth of Massachusetts Regulations

2.2.3.4.1 Massachusetts Protection of Floodplains

Under 310 CMR 40.701, no new active treatment or storage facility receiving hazardous waste from an outside facility may be located within the 100-year floodplain. Any hazardous waste treatment or storage facility located within the 100-year floodplain not receiving waste from an outside facility must be designed for floodproofing such that no floodwaters contact the hazardous waste. No land treatment unit, waste pile, or surface impoundment may be constructed within the 500-year floodplain. MTL is located outside of the flood hazard area bordering the Charles River (as shown in Figure 2-1), with the exception of the southern portion of the park area between North Beacon Street and the river, which is within the 100- and 500-year flood zone.

2.2.3.4.2 Massachusetts Historical Commission Regulations

The Massachusetts Historical Commission Regulations (950 CMR 70-71) were established to minimize or mitigate adverse effects to properties listed in the State Register of Historic Places. MTL is listed in the State Register. The regulations contain standards that protect the public's interest in preserving historic and archaeological properties as early as possible in the planning process of any project. Requirements include notification to the Massachusetts Historical Commission (MHC). MHC will make a determination as to whether the actions planned will have an adverse impact. If so, the MHC and party responsible for the action will consult to determine ways to minimize adverse impacts.

2.2.4 ACTION-SPECIFIC ARARs FOR THE MTL SITE

Action-specific ARARs are usually technology- or activity-based requirements or limitations. These requirements are triggered by the particular remedial activities that are selected to accomplish an alternative. Since there are usually several alternative actions for any remedial site, various requirements may be applicable or relevant and appropriate. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved.

2.2.4.1 RCRA

Massachusetts has a delegated RCRA program for most of the requirements established by EPA. Exceptions to this are certain subparts which regulate specific treatment technologies (such as incineration and thermal treatment) and land disposal restrictions. Therefore, state hazardous waste regulations supersede most federal RCRA requirements. The following subsections discussing RCRA deal with only those parts which are not superseded by state regulations. A discussion of state hazardous waste regulations can be found in Subsection 2.2.4.3.

2.2.4.1.1 Excavation and Land Disposal Restrictions (LDRs)

Excavation and movement of excavated materials from their original location may trigger land disposal restrictions under RCRA (40 CFR 268). Under these restrictions, treatment of the materials excavated will be required before ultimate disposal on land.

EPA has concluded that moving RCRA hazardous waste constitutes disposal when the waste is moved from one unit and placed in another unit. In many cases, an area of contamination at a CERCLA site with differing concentration levels of hazardous substances can be viewed as a single large "unit." In such cases, when the waste is moved from one part of the unit to another, disposal has not occurred (53 FR 51407). The preamble to the rule set forth in 53 FR 51407 stated EPA's interpretation that when noncontiguous facilities are reasonably close to one another and wastes at these sites are compatible for a selected treatment or disposal approach, CERCLA section 104(d)(4) allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit.

With EPA's interpretation of the regulations in mind, soils can be excavated and staged on-site without triggering land disposal restrictions.

Land disposal is defined to include any placement of a listed RCRA hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome or salt bed formation, or underground mine or cave; therefore, RCRA LDRs would apply at MTL if hazardous waste were removed and placed outside of the current area of contamination; removed, treated, and placed back in the original area of contamination; or removed and shipped to an off-site TSDF. At this time, it has not been concluded that RCRA hazardous wastes are present on-site, but the possibility does exist; therefore, LDRs are considered potential ARARs. If hazardous wastes are

found, they will be hazardous by characteristic; there are no listed hazardous wastes on-site at MTL.

Land disposal of a RCRA hazardous waste is regulated under 40 CFR 268. EPA must promulgate treatment standards for all hazardous wastes. Established treatment standards are presented under Subpart D of 40 CFR 268. Wastes that meet these treatment standards may be directly land-disposed. Wastes that do not meet these standards must be treated to meet the corresponding standard before they are placed in a land disposal unit. The treatment standards are expressed as either:

- A concentration level to be achieved (performance based) using any available technology to meet the standard.

- A specified Best Demonstrated Available Technology (BDAT) that must be used (technology based).

Hazardous wastes that do not meet the treatment standards are prohibited from land disposal under Subpart C of 40 CFR 268. Furthermore, under Subpart E of 40 CFR 268, the following prohibitions are placed on storage of such restricted wastes:

- Generators may store such wastes in tanks or containers on-site solely to accumulate such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal.

- TSDFs may store such wastes in tanks or containers solely to accumulate such quantities of hazardous waste as necessary to facilitate proper recovery, treatment, or disposal.

The applicable treatment standards for land disposal are the Universal Treatment Standards for characteristic hazardous wastes. Since in many cases these levels are set above the hazardous level established by TCLP, it is possible for a characteristic hazardous waste to achieve the applicable universal treatment standards without further treatment.

As mentioned previously, soils at MTL have not yet been confirmed as hazardous wastes. If any hazardous waste soils are determined, they would be classified as characteristic wastes based on TCLP results. Since a direct source cannot be linked with any characteristic hazardous wastes, the soils may be considered under the EPA Contained-In Policy. Under this policy, soils containing a hazardous waste can be classified as nonhazardous once they were treated to remove the hazardous characteristic. Treated soils under the Contained-In Policy are not subject to LDRs or other parts of RCRA.

2.2.4.1.2 Incineration

If incineration is considered a remedial action at MTL, RCRA regulations governing incineration represent potential ARARs. Incineration of a RCRA hazardous waste is

regulated under 40 CFR 264 and 265, Subpart O. These regulations include provisions for:

- Waste feed analysis (40 CFR 264.341 and 265.341).
- Operating requirements (40 CFR 264.345 and 265.345).
- Monitoring and inspections (40 CFR 264.347 and 265.347).
- Closure with disposal of all hazardous waste and residues, including ash, scrubber water, and scrubber sludge (40 CFR 264.351 and 265.351).
- Compliance with additional general TSDF requirements.

In addition, the regulations establish performance standards for incineration (40 CFR 264.342 and 264.343) that include:

- Achieving a destruction and removal efficiency (DRE) of 99.99% for each principal organic hazardous constituent (POHC) in the waste feed.
- Reducing hydrogen chloride (HCl) emissions to 1.8 kg/hr or 1% of the HCl in the stack gas before they enter any pollution control device.
- Not releasing particulate matter in excess of 180 mg/m^3, corrected for the amount of oxygen in the stack gas.

The ability to meet these performance standards must be demonstrated during a trial burn period.

2.2.4.1.3 Thermal Treatment

If thermal treatment is considered as a remedial action at MTL, RCRA regulations governing thermal treatment represent potential ARARs. Thermal treatment of a RCRA hazardous waste is regulated under 40 CFR 265, Subpart P. These regulations include provisions for the following items:

- Operating requirements (40 CFR 265.373).
- Waste analysis (40 CFR 265.375).
- Monitoring and inspections (40 CFR 265.377).
- Closure (40 CFR 265.381).

In addition, the regulations prohibit open burning of hazardous wastes except waste explosives and selected "F" series wastes (40 CFR 265.382 and 265.383).

2.2.4.1.4 Chemical, Physical, And Biological Treatment

The regulations in 40 CFR 265, Subpart Q, potentially apply to remedial actions at MTL if the facility is to treat RCRA hazardous wastes using chemical, physical, or biological methods other than treatment in tanks, surface impoundments, and land treatment facilities. These regulations include provisions for:

- Operating requirements (40 CFR 265.401).
- Waste analysis and trial tests (40 CFR 265.402).
- Inspections (40 CFR 265.403).
- Closure (40 CFR 265.404).

In addition, the regulations have special requirements for reactive and incompatible wastes.

2.2.4.1.5 Air Emissions

The regulations in 40 CFR 264 Subpart AA potentially apply to remedial actions at MTL if the organic concentration in soil exceeds 10 ppm by weight. These regulations deal with air emission standards from process vents from any treatment unit where air emissions may occur.

The regulations in 40 CFR 264 Subpart BB potentially apply to remedial actions at MTL if the organic concentration in soil exceeds 10% by weight. These regulations deal with air emission standards for equipment leaks from any equipment used in connection with a TSDF.

2.2.4.2 National Emission Standards for Hazardous Air Pollutants

The Clean Air Act (CAA) (42 USC 7401 et seq.) mandates EPA to establish regulations to protect ambient air quality. As such, it may be applied as an ARAR to MTL for remedial actions that potentially result in air emissions from activities such as excavation and incineration .

National Emission Standards for Hazardous Air Pollutants (NESHAPs) set air emission standards for 189 hazardous air pollutants from designated source activities. Since site remediation is a designated activity, remedial activities must be designed to meet Maximum Available Control Technology (MACT).

2.2.4.3 Commonwealth of Massachusetts Regulations

2.2.4.3.1 Hazardous Waste Regulations

Massachusetts hazardous waste regulations are presented in 310 CMR 30. These requirements may be applicable to MTL because contaminated materials found at the property could be considered state hazardous wastes (either listed or characteristic hazardous wastes).

Hazardous waste identification is detailed in 310 CMR 30.100. The two basic classifications of RCRA hazardous wastes are as follows:

- Listed hazardous wastes that involve specific identification of the following regulatory listings:
  - Hazardous Waste from Nonspecific Sources (F-series wastes and MA wastes listed under 310 CMR 30.131).
  - Hazardous Waste from Specific Sources (K-series wastes listed under 310 CMR 30.132).
  - Commercial Chemical Products (P- and U-series wastes listed under 310 CMR 30.133).
- Characteristic hazardous wastes (defined under 310 CMR 30.120) that involve evaluation of the following general waste characteristics:
  - Ignitability (D001 waste).
  - Corrosiveness (D002 waste).
  - Reactivity (D003 waste).
  - Toxicity (D004 to D043 wastes) that is due to specific chemical compounds.

If a waste is not a listed hazardous waste, it may still be a hazardous waste if it meets any of the four aforementioned characteristics; these characteristics can be determined by specific tests cited in the regulations. Alternatively, if knowledge of the source or properties of a waste indicates that it may have any of these characteristics, the material may be declared hazardous without being tested. Exceptions are cited in the regulations.

None of the soils at MTL have yet been identified as a hazardous waste. The contaminated soils are not considered a listed hazardous waste because none of the state waste codes (310 CMR 30.130) apply to these soils. In addition, the soils have not yet been tested for hazardous waste characteristics (toxicity, using the Toxicity Characteristic Leachate Procedure [TCLP]; ignitability; reactivity; and corrosivity). Of these characteristics, toxicity (TCLP test) appears to be the only one with the potential to cause MTL soils to be listed as a hazardous waste; therefore, MTL soils to be remediated must be analyzed by the TCLP test to determine whether they are a hazardous waste. Table 2-2 specifies the TCLP constituents detected in MTL soils.

Although no TCLP data exist, one generally accepted method was used to estimate whether soils could potentially fail the TCLP test. The soil contaminant concentration was divided by 20. (The TCLP test attempts to leach soil contaminants. The test

Table 2-2

TCLP Constituents Detected in Site Soils to be Remediated

EPA Hazardous Waste Number	Constituent
D004	Arsenic
D005	Barium
D006	Cadmium
D020	Chlordane*
D022	Chloroform
D007	Chromium
D012	Endrin
D031	Heptachlor/Heptachlor Epoxide*
D032	Hexachlorobenzene
D008	Lead
D013	Lindane
D009	Mercury

*Identified by the Risk Assessment as a contaminant triggering remedial action.

procedure mixes the soil with the leaching solution, resulting in a dilution factor of 20 times. This final concentration is compared to the regulatory standards to determine whether the sample has failed; therefore, the estimating method assumes worst possible conditions, i.e., that 100% of the soil contaminants would leach.) If 1/20 of the contaminant concentration exceeds the regulatory concentration specified in 310 CMR 30.125B, then this method predicts that the soil sample could, under worst-case conditions, fail the TCLP test, in which case the soil is a characteristic hazardous waste.

Using this method, analysis of the RI data indicates that certain soils at MTL could fail the TCLP test for lead, chlordane, chromium, endrin, and heptachlor epoxide if all the contaminants were leachable. In particular, at least one sample from 16 of the 18 sample units at MTL contains lead concentrations that could possibly fail the TCLP analysis. In addition, soils in 10 of the 18 units could fail the TCLP analysis because of chlordane concentrations.

Since Massachusetts has a delegated RCRA program for most aspects of hazardous waste regulations, the following state regulations are action-specific ARARs for this site:

- Hazardous Waste Facility Management Standards - 310 CMR 30.500.
- Generator Requirements - 310 CMR 30.300.
- Waste Piles - 310 CMR 30.640.
- Use and Management of Containers - 310 CMR 30.680.
- Storage and Treatment in Tanks - 310 CMR 30.690.

Each of these are discussed below.

Hazardous Waste Facility Management Standards - TSDF requirements under state RCRA apply to facilities that treat, store (for greater than 90 days), or dispose of hazardous wastes. TSDF requirements are potential ARARs relevant to MTL for remedial actions involving TSDF activities with on-site materials qualifying as hazardous wastes. Specific requirements include:

- General facility standards (310 CMR 30.510).
- Preparedness and prevention standards, contingency plan, and emergency procedures (310 CMR 30.520).
- Closure and post-closure requirements (310 CMR 30.580-590).

Generator Requirements - Generator requirements under state hazardous regulations apply to individuals who generate hazardous wastes. Generator requirements (310 CMR 30.300) are potential ARARs at MTL for remedial actions that generate residues determined to be hazardous wastes. General provisions include:

- Hazardous waste determinations and EPA identification numbers (310 CMR 30.301-305).
- Manifesting requirements (310 CMR 30.310).

- Pretransport requirements (310 CMR 30.320).

Waste Piles - Waste piles are defined under 310 CMR 30.010 as "any noncontainerized aggregation of solid, nonflowing hazardous waste that is being treated or stored." As remedial actions involving excavation could occur at MTL, waste pile regulations are potential ARARs. Waste piles are regulated under 310 CMR 30.640. Requirements include:

- Design and operating requirements (310 CMR 30.641).
- Monitoring and inspection (310 CMR 30.644).
- Demonstration of waste/liner compatibility (310 CMR 30.645).
- Special requirements for special wastes (310 CMR 30.646).

Use and Management of Containers - 310 CMR 30.680 applies to owners and operators of all hazardous waste facilities that store containers of hazardous waste. Since remedial actions at MTL will likely require the use of containers for handling field-generated hazardous waste, the following subsections would apply:

- Management of containers (310 CMR 30.685).
- Compatibility of waste with containers (310 CMR 30.684).
- Inspections (310 CMR 30.686).
- Containment (310 CMR 30.687).
- Closure (310 CMR 30.689).

Storage and Treatment in Tanks - 310 CMR 30.690 applies to owners and operators of all hazardous waste facilities that treat or store wastes in tanks. Remedial actions at MTL may involve the use of tanks; the following subsections would apply:

- General requirements for tank design (310 CMR 30.692).
- Secondary containment for above-ground tanks (310 CMR 30.694).
- General operating requirements (310 CMR 30.695).
- Inspections (310 CMR 30.696).
- Response to leaks or spills (310 CMR 30.697).
- Closure and post-closure (310 CMR 30.699).

2.2.4.3.2 Solid Waste Requirements

Massachusetts requirements for solid waste management are contained in 310 CMR 19. These provisions establish standards applicable to the treatment, storage, and disposal of solid waste and the closure of solid waste facilities. Nonhazardous solid waste on-site must be managed, stored, treated, and disposed of in accordance with the solid waste management rules.

A specific part of these rules that may be applicable to MTL are the rules for the handling of Special Waste. Special Waste is defined as nonhazardous waste that requires controls to prevent an adverse impact to human health or the environment from its collection, transportation, treatment, storage, or disposal. Any nonhazardous

requires controls to prevent an adverse impact to human health or the environment from its collection, transportation, treatment, storage, or disposal. Any nonhazardous excavated soil or treatment sludges or residues may be deemed as Special Wastes and must be managed in accordance with the regulations.

2.2.4.3.3 Air Emissions

Massachusetts air regulations are contained in 310 CMR 6-8. These regulations outline ambient air quality standards and air pollution control regulations. They include requirements for emission limitations, design specifications, and permitting. Massachusetts Air Pollution Control Regulations (310 CMR 7) establish specific emissions limitations and are action-specific requirements for this site. These regulations would be applicable at MTL for any emissions resulting from remedial actions. Specific sections of the regulations that may be applicable include:

- Visible emissions - 310 CMR 7.06.
- Incinerators - 310 CMR 7.08.
- Dust, Odor, Construction, and Demolition - 310 CMR 7.09.
- Noise - 310 CMR 7.10.
- Volatile Organic Compounds (VOCs) - 310 CMR 7.18.

2.2.5 TBC INFORMATION

TBC information refers to other federal and state criteria, advisories, guidance, and proposed standards and local ordinances that are not legally binding but may provide useful information or recommended procedures.

2.2.5.1 EPA Risk Reference Doses

Reference doses are dose levels of contaminants that are developed based on the noncarcinogenic effects of contaminants. This information is used during the risk assessment to develop a Hazard Index for noncarcinogenic risk.

2.2.5.2 EPA Carcinogen Assessment Group Potency Factors

Potency factors are developed by EPA from health effects assessments or evaluation by the Carcinogenic Assessment Group. These factors are used in risk assessment to develop cancer risks.

2.2.5.3 Federal Test Methods for Evaluating Solid Waste

This information is provided in the EPA Publication SW-846 entitled "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods." This guidance document sets forth the proper methodology for conducting analytical sample analysis using EPA-approved methods. This guidance is used for any soil analysis at Superfund sites.

2.2.5.4 EPA Guidance on PCB Cleanup Levels at Superfund Sites

EPA has issued cleanup goals for PCBs at Superfund sites as per OSWER Directive No. 9355.4-01. These goals are published in the EPA document Guidance on Remedial Actions for Superfund Sites with PCB Contamination, August 1990. In this document, EPA establishes PCB cleanup goals in soil to be 1 ppm for residential land use and 10-25 ppm for industrial use. The 1 ppm level generally corresponds to a 10^{-5} excess cancer risk level.

2.2.5.5 Commonwealth of Massachusetts Policy on Allowable Sound Emissions

The Division of Air Quality Control (DAQC) Policy 90-001 considers sound emissions to be in violation of 310 CMR 7.10 if the source increases the broadband sound level by more than 10 dB(A) above ambient, or produces a "pure tone" condition (when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more). These criteria are measured at both the property line and at the nearest inhabited residence.

2.3 TARGET SOIL CLEANUP GOALS

The Risk Assessment concludes that certain site soils present unacceptable health risks to human health [i.e., excess cancer risk greater than 1 in 100,000 (1E-5) or noncancer health hazards exceeding a hazard index (HI) value of 1]. The terrestrial ecological risk assessment indicated a potential for adverse effects (HI exceedences) to ecological receptors. Federal (EPA) policy regarding CERCLA sites states that remedial measures are required when potential cancer risks exceed less than 1 in 10,000 (1E-4) to 1 in 1,000,000 (1E-06) or a noncancer health HI value less than 1. The MCP requires that total site risk not be greater than 1E-05. The RI and previous versions of this FS were written according to MCP requirements; therefore, a 1E-05 total site cancer risk has been used as the action level to determine remedial goals. While this is not the standard approach for a Superfund site, this methodology is more conservative than the use of the EPA cancer risk range. This methodology was previously approved by EPA.

Because of future reuse possibilities for the MTL site, the site was divided into four different zones, not including the River Park (as per the Reuse Plan developed by the Watertown Arsenal Reuse Committee). These zones are shown in Figure 2-3. Each of the four zones has two possible reuse scenarios: Zones 1, 2, and 3 could be reused for commercial or residential purposes and Zone 4 could be reused for a residential or for an open public area. Because of the different zones and the different reuse possibilities for each zone, risk for MTL was evaluated separately for each zone and each reuse possibility of each zone. Cleanup goals derived from human health risks were then developed for each of the zone reuse scenarios. The contaminants of concern for human health were then compared to the contaminants of concern established in the ecological risk assessment. The ecological assessment was limited only to those open nonpaved areas of the site (Zone 4 and the River Park) and is applicable only in these areas.

2.3.1 Risk to Human Health

A summary of the human health risk scenarios is presented in Tables B-2 to B-10 in Appendix B. To meet selected site criteria, any scenario with a total site carcinogenic risk greater than 1E-5 or a noncarcinogenic hazard index greater than 1 would require remediation. It should be noted that total risk for a particular zone may also include exposures from areas outside that zone. For example, exposure points for residential reuse of Zones 1, 2, or 3 include the River Park, the Charles River, and the open area of Zone 4 as well as exposure within Zone 1, 2, or 3. It should also be noted that for residential risk in a zone, risk for soil excavation was evaluated for Zones 1 and 4, meaning that risk was evaluated assuming new residential structures would be built. Zones 1, 2, 3, and 4 were also evaluated for residential risk assuming no soil excavation (no new structures).

From the Risk Assessment, the determination was made that certain scenarios did not result in sufficient risk to warrant remediation (these scenarios include commercial reuse of Zone 1 and site construction workers); therefore, no cleanup goals were determined for these scenarios. In addition, the noncarcinogenic HI value of 1 was not exceeded in Zone 1, 2, or 3; therefore, there was no further evaluation of noncarcinogenic risks for these zones to determine cleanup levels.

Tables B-2 to B-10 make clear that to reduce total carcinogenic risk to below 1E-5 for residential reuse of any of the zones or for River Park visitors, several exposure areas would require remediation, but not every exposure pathway needs to be addressed to achieve the goal. It was determined that if the cancer risk for each exposure route for the zone and River Park soils were reduced to 1E-06, then the total risk would not exceed 1E-05. This would also mean that no remediation of Charles River surface water or sediment (additional exposure points) would be necessary to reduce site risk to below 1E-05 based on human health.

For residential reuse of Zone 1, 2, or 3, the exposures requiring evaluation included ingestion of zone soil, dermal contact with zone soil, ingestion of vegetables grown in soil (Zone 1 only), ingestion of Zone 4 open area soil, dermal contact with Zone 4 open area soil, and ingestion of River Park soil. For residential reuse of Zone 4, the exposures requiring evaluation included ingestion of zone soil, dermal contact with zone soil, ingestion of vegetables grown in zone soil, and ingestion of River Park soil. River Park was also considered separately for park visitor use; exposures included ingestion and dermal contact with soil. Risk-based cleanup goals were determined so that each of the above exposures had a total risk of 1E-06. Since risks are additive according to risk assessment protocols, this resulted in an overall zone risk of less than 1E-05.

For commercial reuse of Zone 1, 2, or 3, the only exposure route is ingestion of zone soil; therefore, cleanup goals for commercial reuse were developed so that the overall risk for this exposure route was less than 1E-05. As a result, numerical cleanup goals for commercial reuse of a zone would be less stringent than for residential reuse.

In the first step to determine risk-based cleanup goals for each reuse scenario of each zone, the Risk Assessment results were screened to determine which individual chemical compounds resulted in unacceptable health risks. For a residential reuse scenario, this meant that all chemicals with a risk above 1E-07 for a particular exposure route (e.g., soil ingestion, dermal contact, and vegetable ingestion) were considered as contaminants of concern. For a commercial reuse scenario, all chemicals with a risk above 1E-06 for an exposure route were considered to be contaminants of concern. For the noncarcinogenic HI scenario, chemicals with an individual index above 0.1 were considered as contaminants of concern.

Second, target risks for individual chemicals were selected. For residential reuse and public visitor scenarios, individual chemical target risks (additive risk for soil ingestion, dermal contact, and vegetable ingestion pathways, where appropriate) were selected at 1E-07. For commercial reuse, target risks for individual chemicals were selected at 1E-06. For the noncarcinogenic HI, the individual chemical target risk was selected at 0.1.

Third, cleanup goals for individual chemicals for each reuse scenario were calculated using the following formulas:

Carcinogenic Risk

$$\text{Cleanup Goal } (\mu g/g) = \frac{\text{Target Risk}}{SF_O \times (HIF_O + [BCF_V \times HIF_V]) + (SF_D \times HIF_D \times AB_S)}$$

where:

HIF_O = Soil ingestion human intake factor
HIF_D = Dermal contact human intake factor
HIF_V = Vegetable ingestion human intake factor
SF_O = Cancer slope factor for oral route
SF_D = Cancer slope factor for adjusted dermal absorption
BCF_V = Chemical specific bioconcentration factor for soil into vegetables
AB_S = Chemical specific dermal contact absorption factor.

Noncarcinogenic Risk

$$\text{Cleanup Goal } (\mu g/g) = \frac{\text{Risk Assessment Soil Concentration } (\mu g/g) \times \text{Target HI}}{\text{Risk Assessment Soil HI}}$$

Risk Assessment soil concentrations, risk assessment soil risks, and all factors for the above equation were presented in the RI.

A summary of the individual human health chemical risk-based goals for each reuse scenario for each zone reuse scenario is presented in Table B-11 in Appendix B. Sometimes in calculating the individual chemical cleanup goals based on carcinogenic risk, not all the terms in the above equation were necessary (i.e., the chemical did not exhibit risk for all the pathways of concern). When this occurred, the equation factors

not needed were given a value of zero in the cleanup goal calculation for the specific chemical. In Table B-11, the equation factors are listed for each chemical in each zone and reuse scenario. Any equation factors not used in the cleanup goal calculation have been given a "-" designation in the table to indicate that they were not included in the calculation, because the particular pathway did not exhibit sufficient risk.

For some contaminants, this methodology resulted in different cleanup goals for the same contaminant in the particular zone reuse scenario (i.e., different goals based on carcinogenic and noncarcinogenic risk). Where this occurred, the contaminant cleanup goal for the zone reuse scenario was chosen to be the more stringent of the cleanup levels. The carcinogenic risk was consistently more stringent than the noncarcinogenic risk. As a result, no cleanup goals were based on the hazard indices. The human health risk-based cleanup goals for the zones and reuse scenarios are summarized in Table 2-3. This table also shows the analytical detection limits for the contaminants. Because of the conservative nature of the risk assessment methodology and MCP criteria, in many cases the risk-based cleanup goals are lower than the detection limit. In all cases, the risk-based cleanup goals are lower than site background levels. It is not appropriate to require remediation of MTL soils to concentrations below background. This is not a requirement of the NCP or the MCP. Therefore, the risk-based cleanup goals were not used as actual remediation cleanup goals. The risk-based cleanup calculations determined the contaminants of concern for each zone reuse scenario. The actual remediation cleanup levels for these contaminants of concern were site background levels.

2.3.2 Ecological Risk

A summary of the terrestrial ecological risk assessment results is provided in Subsection 1.2.4.3.2. The contaminants of potential concern addressed in the ecological risk assessment include pesticides, PAHs, and metals.

In order to reduce the risks to terrestrial ecological receptors from the contaminants of concern, ecologically-based clean-up levels were developed. Chemical-specific clean-up levels were calculated for the short-tailed shrew and the American robin based on a hazard index of 10. A hazard index of 10 was established by EPA for this site as an acceptable goal, since clean-up goals based on a hazard index of 1 yielded clean-up levels below background and analytical detection limits. The models used for these calculations are presented in Tables 2-4 and 2-5 for the shrew and robin, respectively. The calculated clean-up goals are presented in Table 2-6. Also presented in Table 2-6 are the maximum contaminant concentrations detected in Zone 4 and the River Park. The reference toxicity values (RTVs) and bioaccumulation factors (BAFs) used in the calculation of the clean-up levels are presented in Appendix B, Tables B-12 through B-15.

Based on a review of the ecological clean-up levels, the ecological risk assessment results, and the analytical data for the site, the following conclusions have been drawn:

- The results of the ecological risk assessment show that the concentrations of PAHs at the site in Zone 4 and the River Park do not pose a risk to

Table 2-3

MTL Zone Human Health Risk-Based Cleanup Goals (mg/kg)

Chemical	Analytical Detection Limit	Zone 1 Commercial Reuse	Zone 1 Residential Reuse	Zone 2 Commercial Reuse	Zone 2 Residential Reuse	Zone 3 Commercial Reuse	Zone 3 Residential Reuse	Zone 4 Residential Reuse	Zone 4 Open Space	River Park
Aldrin	-	-	-	-	1.4E-02	-	-	1.1E-02	-	-
Alpha-chlordane	-	-	5.3E-02	-	1.8E-01	-	-	5.3E-02	-	-
Benzo[a]anthracene	4.1E-02	-	7.0E-03	8.1E-01	3.3E-02	8.1E-01	3.3E-02	7.0E-03	1.1E-01	2.1E-01
Benzo[a]pyrene	1.2	-	-	8.1E-01	3.3E-02	8.1E-01	3.3E-02	6.0E-03	1.1E-01	2.1E-01
Benzo[b]fluoranthene	3.1E-01	-	6.0E-03	8.1E-01	3.3E-02	8.1E-01	3.3E-02	6.0E-03	1.1E-01	2.1E-01
Benzo[k]fluoranthene	1.3E-01	-	4.1E-03	8.1E-01	3.3E-02	8.1E-01	3.3E-02	4.1E-03	1.1E-01	2.1E-01
Chlordane	6.8E-02	-	5.3E-02	-	1.8E-01	-	1.8E-01	5.2E-02	5.9E-01	-
Chrysene	3.2E-02	-	7.0E-03	-	3.3E-02	8.1E-01	3.3E-02	7.0E-03	1.1E-01	2.1E-01
4,4'-DDD	2.7E-03	-	-	-	-	-	-	2.5E-01	-	-
4,4'-DDE	2.7E-03	-	1.9E-01	-	-	-	-	1.9E-01	-	-
4,4'-DDT	3.5E-03	-	1.3E-01	-	-	-	-	1.3E-01	-	-
Dibenz[a,h]anthracene	3.1E-01	-	-	-	3.3E-02	-	3.3E-02	4.1E-03	-	2.1E-01
Dieldrin	1.6E-03	-	7.1E-03	-	1.5E-02	-	-	7.1E-03	-	-
Gamma-chlordane	-	-	-	-	-	-	-	5.3E-02	-	-
Heptachlor epoxide	1.3E-03	-	8.2E-03	-	2.6E-02	-	-	6.2E-03	-	-
Indeno[1,2,3-c,d]pyrene	2.4	-	-	8.1E-01	3.3E-02	8.1E-01	3.3E-02	4.9E-03	1.1E-01	2.1E-01
Aroclor 1260	4.8E-02	-	1.7E-03	-	1.3E-02	-	1.3E-02	1.7E-03	3.1E-02	-
Beryllium	4.3E-01	-	1.1E-02	-	1.1E-02	-	1.1E-02	1.1E-02	2.3E-02	3.6E-01

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Table 2-4

Model for Calculating Soil Clean-Up Levels Based on the Northern Short-Tailed Shrew

$$\text{Risk-Based Clean-up Level (mg/kg)} = \frac{RTV \times HI \times BW}{FI \times (SIR + BAF \times EIR)}$$

Where:

RTV = Chemical-specific reference toxicity value (mg/kg-day)

HI = Target Hazard Index (unitless)

BW = Body weight (kg)

FI = Fraction ingested from contaminated source (unitless)

SIR = Soil ingestion rate (g dry weight/day)

BAF = Chemical-specific bioaccumulation factor (unitless)

EIR = Earthworm ingestion rate (g dry weight/day)

Exposure Assumptions

RTV = Chemical-specific RTVs (mg/kg-day) are presented in Table B-12 (Appendix B).

HI = 10 (assumed)

BW = 0.015 kg (EPA, 1993)

FI = 1[a]

SIR = 0.29 g dry weight/day[a]

BAF = Chemical-specific BAFs (unitless) are presented in Table B-14 (Appendix B).

EIR = 2.8 g dry weight/day (EPA, 1993)

[a]Assumes home range of the shrew falls within the site area.

Table 2-5

Model for Calculating Soil Clean-up Levels Based on the American Robin

$$\text{Risk-Based Clean-up Level (mg/kg)} = \frac{RTV \times HI \times BW}{FI \times (SIR + BAF \times EIR)}$$

Where:

RTV	=	Chemical-specific reference toxicity value (mg/kg-day)
HI	=	Target Hazard Index (unitless)
BW	=	Body weight (kg)
FI	=	Fraction ingested from contaminated source (unitless)
SIR	=	Soil ingestion rate (g dry weight/day)
BAF	=	Chemical-specific bioaccumulation factor (unitless)
EIR	=	Earthworm ingestion rate (g dry weight/day)

Exposure Assumptions

RTV	=	Chemical-specific RTVs (mg/kg-day) are presented in Table B-13 (Appendix B).
HI	=	10 (assumed)
BW	=	0.077 kg (Dunning, 1984)
FI	=	1[a]
SIR	=	1.7 g dry weight/day[b]
BAF	=	Chemical-specific BAFs (unitless) are presented in Table B-14 (Appendix B).
EIR	=	16 g dry weight/day (Nagy, 1987; EPA, 1993)

[a] Assumes home range of the robin falls within the site area.
[b] Assumed to be 10.4% of food intake (EPA, 1993).

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Table 2-6

MTL Ecological Risk-Based Soil Cleanup Levels for Zone 4 and River Park Based on a Hazard Index = 10

Chemical	Maximum Contaminant Concentration in Ecologically Sensitive Areas (mg/kg)	Soil Cleanup Level Based on Exposure to Shrew (mg/kg)	Soil Cleanup Level Based on Exposure to Robin (mg/kg)	Most Conservative Cleanup Level (mg/kg)
Benzo(a)anthracene	3.15E+01	3.73E+03	N/A	3.73E+03
Benzo(a)pyrene	3.66E+01	3.14E+03	N/A	3.14E+03
Benzo(b)fluoranthene	1.54E+01	4.44E+03	N/A	4.44E+03
Benzo(g,h,i)perylene	1.36E+01	5.49E+03	N/A	5.49E+03
Benzo(k)fluoranthene	2.36E+01	4.44E+03	N/A	4.44E+03
Chlordane	9.36E+00	1.36E+00	1.98E+01	1.36E+00
Chrysene	3.39E+01	2.56E+03	N/A	2.56E+03
4,4'-DDD	3.48E+00	3.09E+01	1.37E+01	1.37E+01
4,4'-DDE	6.33E+00	6.25E+00	1.41E-01	1.41E-01
4,4'-DDT	5.20E+00	1.00E+00	1.66E-01	1.66E-01
Dieldrin	3.12E-01	3.53E-01	1.15E+00	3.53E-01
Dibenz(a,h)anthracene	3.34E+00	2.35E+03	N/A	2.35E+03
Endrin	5.00E-01	7.23E-01	3.12E-01	3.12E-01
Fluoranthene	5.41E+01	2.94E+03	N/A	2.94E+03
Fluorene	1.05E+00	4.41E+03	N/A	4.41E+03
Indeno(1,2,3-cd)pyrene	1.04E+01	2.71E+03	N/A	2.71E+03
Pyrene	5.26E+01	2.82E+03	N/A	2.82E+03
PCB (Aroclor 1260)	4.87E+00	3.34E+00	1.02E+01	3.34E+00
Arsenic	5.20E+01	1.34E+01	1.81E+03	1.34E+01
Cadmium	3.53E+00	3.74E+00	8.18E+00	3.74E+00
Chromium	7.12E+01	1.12E+01	1.04E+03	1.12E+01
Copper	1.55E+03	5.12E+03	9.69E+02	9.69E+02
Lead	5.21E+02	7.78E+01	3.93E+02	7.78E+01
Manganese	1.29E+03	1.40E+03	1.02E+04	1.40E+03
Nickel	9.92E+01	7.88E-01	8.58E+01	7.88E-01
Zinc	8.49E+02	1.07E+02	2.45E+02	1.07E+02

ecological receptors. The ecological clean-up goals derived for PAHs are greater than the concentrations of PAHs detected at the site. Thus, it is not necessary to remediate for PAHs at the site to reduce risk to ecological receptors. PAHs, however, will be remediated at select locations at the site to reduce human health risks.

- The results of the ecological risk assessment show that the concentrations of pesticides in Zone 4 and the River Park pose a risk to ecological receptors. HIs greater than 10 were estimated for the shrew based on concentrations of chlordane and DDT, and HIs greater than 10 were estimated for the robin based on concentrations of DDT, DDE, and endrin. Concentrations of DDE and chlordane also exceeded toxicity values for soil invertebrates. Select locations (17SOL02, 13SS02, 15SB02, 17SB03, 13SB01) will be remediated to the ecological clean-up goals for pesticides in order to reduce the risk to terrestrial ecological receptors at the site. This is discussed further in Subsection 2.3.3.

- The results of the ecological risk assessment show a risk to the ecological receptors based on exposure to certain metals at the site. The HIs for the short-tailed shrew exceeded 10 for the following metals: arsenic, chromium, lead, nickel, and zinc. Nickel had the largest hazard index (430 based on the 95% upper confidence limit [UCL], and 360 based on the mean), followed by lead (37-UCL; 27-mean) and chromium (24-UCL; 22-mean). The HIs for arsenic (13-UCL) and zinc(15-UCL; 13-mean) only slightly exceeded 10. Concentrations of zinc and copper at the site also exceeded toxicity values for soil invertebrates.

There are, however, substantial uncertainties associated with the estimate of metals risks to ecological receptors. The largest HI estimated for the shrew was for nickel. The RTV used for nickel was based on a drinking water study in which nickel was administered as a soluble salt. Thus, the RTV was based on a very bioavailable form of nickel and may tend to overestimate risks based on nickel exposure. In addition, approximately 95% of the nickel risk was due to the ingestion of earthworms, and there is a great deal of uncertainty associated with the estimation of bioaccumulation of metals in earthworms. Due to these uncertainties, the clean-up goal derived for nickel in soils is overly conservative, and falls within typical background concentrations at various locations (see Table 2-7).

Because of the uncertainties in the exposure and toxicity estimates for metals, and the potential to develop overly conservative clean-up goals, one needs to consider the background levels of metals at the site as a basis for clean up. In the absence of site-specific metals background accepted by all agencies, means and ranges of background metal concentrations measured in U.S. soils were used for comparison to site values. These background data are presented in Table 2-7 for those metals which may potentially pose a risk to ecological receptors. The ranges that are presented often span many orders of magnitude, and are most likely a reflection of the diverse environments that were sampled. Thus, these background values are used as a general guidance in

Table 2-7

Background Concentrations of Metals in U.S. Soils (mg/kg)

Metals	Eastern U.S. Soils[a]		U.S. Various Soils[b]		NJ Soils Urban Areas[c]	MADEP[d]	
	Range	Arithmetic Mean	Range	Mean	Mean	Range	Arithmetic Mean
Arsenic	<0.1 - 73	7.4	<1 - 93.2	7	8.26	<0.1 - 99	8.2
Chromium	1 - 1000	52	7 - 1500	50	12	0.02 - 105	15.2
Copper	<1 - 700	22	3 - 300	26	42.2	<0.5 - 160	16.3
Lead	<10 - 300	17	<10 - 70	26	177.7	1 - 326	39.2
Nickel	<5 - 700	18	<5 - 150	18.5	16.6	<0.5 - 48	7.7
Zinc	<5 - 2900	52	10-300	73.5	127.5	3.52-190	42.6

Sources:
[a] Shacklette and Boerngen, 1984
[b] Kabata-Pendias and Pendias, 1984
[c] NJDEPE, 1992
[d] MADEP, 1995

determining whether a metal is at background levels at the site. Other factors were considered, such as the range and distribution of metal concentrations at the site. Of the metals at the site which pose a potential risk to ecological receptors, those metals which exceeded background ranges at one or more locations were copper, lead, nickel, and zinc. Copper exceeded all background ranges at sampling location 14SUB01 (1550 mg/kg). Lead exceeded maximum background ranges at sampling locations 13SS01, 13SS05, 13SS08, 15SOL02, 15SB02, and 17SB01. Nickel did not exceed background ranges for U.S. eastern and various soils, but exceeded the MADEP background ranges at sampling locations 14SS03, 12SUB01, 14SUB01, 14SUB02, and 15SB02. The highest concentrations of nickel were found at 14SS03 (99.2 mg/kg) and 12SUB01 (73.4 mg/kg). The background ranges for zinc were quite variable. Zinc exceeded background ranges of 300 mg/kg at locations 16SS01 (849 mg/kg), 14SUB01 (639 mg/kg), and 14SS01 (315 mg/kg). Although arsenic and chromium did not exceed background ranges, there were a few values that appeared to be higher than the majority of values measured at the site. The maximum arsenic concentration of 52 mg/kg (sampling location 14SUB01) appears to be slightly higher than other arsenic values. For chromium there are a few values (sampling location 16SS01 and 14SS03) that appear to be slightly elevated.

2.3.3 Cleanup Goal Determination

2.3.3.1 Background Level Determination

Background concentrations for each of the contaminants of concern were determined using a statistical evaluation of site background data. In this evaluation, for organics, background levels were calculated using samples from 0 to 2 ft deep. This is thought to be representative because the deposition of ubiquitous anthropogenic organics takes place most often in the soil surface. The actual organic background data for samples collected below 2 ft had no detectable organics. For beryllium, all background data were used in the evaluation because of the homogeneous distribution of beryllium as verified by the collected site and background data. The data set to determine background for PAHs was expanded to include selected on-site data points in the open space areas of Zone 4 and River Park. These points were included to allow the data set be more representative of open area conditions. The specific data points included with the background data were selected previously by EPA and MADEP in a meeting with AEC held on May 3, 1994.

For organics (pesticides and PAHs), the samples included in the pesticide and PAH background data sets are as follows:

Pesticides	PAHs	PAHs, continued
01SB-3 (2 ft)	01SB-3 (2 ft)	13SS-1 (0 - 0.1 ft)
BKSB-1 (0 ft)	BKSB-1 (0 ft)	13SS-2 (0 - 0.2 ft)
BKSB-2 (0 ft)	BKSB-2 (0 ft)	13SB-2 (0 ft)
BKSB-3 (0 ft)	BKSB-3 (0 ft)	13SS-7 (0.02 ft)
BKSB-4 (0 ft)	BKSB-4 (0 ft)	13SS-8 (0.1 ft)
GRSB-2 (0 ft)	GRSB-2 (0 ft)	14SB-1 (0 ft)
GRSB-3 (0 ft)	GRSB-3 (0 ft)	15SB-1 (0 ft)
01SS-1 (0 - 0.2 ft)	01SS-1 (0 - 0.2 ft)	17SB-1 (0 ft)
03SS-1 (0.1 ft)	03SS-1 (0.1 ft)	

Because site sampling results indicated that beryllium was homogeneously distributed throughout all depths, background data from all sampling depths were used to calculate the 90% UCL for beryllium. The samples included in the beryllium background data set are as follows:

01SB-3 (2 ft)	BKSB-3 (0 ft)	BKSB-4 (12 ft)
01SB-3 (4 ft)	BKSB-3 (4 ft)	GRSB-2 (0 ft)
01SB-3 (6 ft)	BKSB-3 (0 ft)	GRSB-2 (14 ft)
01SB-3 (8 ft)	BKSB-3 (4 ft)	GRSB-3 (0 ft)
01SB-3 (12 ft)	BKSB-3 (8 ft)	GRSB-3 (12 ft)
BKSB-1 (0 ft)	BKSB-3 (12 ft)	01SS-1 (0-0.2)
BKSB-1 (16 ft)	BKSB-3 (14 ft)	03SS-3 (0.1)
BKSB-2 (0 ft)	BKSB-3 (20 ft)	
BKSB-2 (14 ft)	BKSB-4 (0 ft)	

The distribution of the data was determined by plotting the data, which indicated that the majority of the chemicals did not display a normal distribution. As a result, the distribution of all chemicals except for beryllium was assumed to be lognormal.

The statistical evaluation of background concentrations was performed for each chemical identified as having a risk-based cleanup goal. The procedure used to determine the background concentrations was based on the EPA document Supplemental Guidance to the Risk Assessment Guidance to Superfund: Calculating the Concentration Term, May 1992. The methods presented in this document allowed the determination of a 90th upper confidence limit of the arithmetic mean of the background data collected on each contaminant. For most of the contaminants, the h-statistic method was used. The h-statistic is used for log-normal data distributions. This 90th upper confidence level was then used as the site background level which becomes the site cleanup goal for the particular contaminant. These calculations are summarized in Table B-16 in Appendix B.

This approach was used to determine background levels for all but two of the contaminants of concern. The contaminants in which this approach was not used were Aroclor 1260 and beryllium. The cleanup goal for Aroclor 1260 was selected as 1 ppm.

This selection is based on the EPA document Guidance on Remedial Actions for Superfund Sites with PCB Contamination. The 1 ppm goal is both for residential and commercial future use. For beryllium, the h-statistic approach was deemed to be invalid because the data distribution for this contaminant was not considered log-normal; it exhibited normal distributions. Therefore, to calculate the 90th upper confidence level, the z-statistic approach was used. The calculated 90th upper confidence level from this method was used as the background/cleanup goal for this contaminant. These calculations are summarized in Table B-16 in Appendix B.

The equations listed below, as presented in Supplemental Guidance to the Risk Assessment Guidance to Superfund: Calculating the Concentrations Term (EPA, 1992), were used to calculate the upper 90% confidence limit of the mean for lognormally and normally distributed data, respectively.

Calculation for the UCL of the Arithmetic Mean for a Lognormal Distribution:

$$UCL = e^{(x + 0.5s^2 + sH/\sqrt{n-1})}$$

Where:

UCL	=	Upper 90% confidence limit.
e	=	Constant (base of the natural log, equal to 2.718).
x	=	Mean of the transformed data (log of the geometric mean).
s	=	Standard deviation of the transformed data.
H	=	H-statistic (Gilbert, 1987).
n	=	Number of samples.

Calculation of the UCL of the Arithmetic for a Normal Distribution:

$$UCL = x + (z \times s)$$

Where:

UCL	=	Upper 90% confidence limit.
x	=	Mean of the untransformed data.
s	=	Standard deviation of the untransformed data.
z	=	Z-statistic (Daniel, 1987).

In calculating the arithmetic mean and 90% UCL of the mean, non-detects were incorporated as one-half the sample quantitation limit.

2.3.3.2 Selection of Cleanup Goals

The results from the above background analysis were compared to the risk-based goals shown in Table 2-3. In selecting soil cleanup goals based on human health, the background concentration of the contaminants of concern was chosen unless the risk-based goal exceeded background. For the contaminants of concern, the cleanup goals were all based on background concentrations except for 4,4'-DDD and Aroclor 1260. The cleanup goal for 4,4'-DDD is risk-based since this exceeded background concentrations. The cleanup goal for Aroclor 1260 is not based on background concentrations or risk-based levels; this cleanup goal is based on the EPA issued cleanup levels for PCBs (see Subsection 2.2.5). The cleanup goal for Aroclor 1260 was 1 ppm, which is the cleanup value for residential soil use. These soil cleanup goals for each zone reuse scenario are summarized in Table 2-8.

Using the cleanup goals in Table 2-8, the residual risk to human health from these concentrations was calculated using the carcinogenic risk equation from Subsection 2.3.1. The exposure scenario selected for residual risk determination was residential exposures to both by ingestion and dermal contact. Table 2-9 presents the individual residual risks from each contaminant and the total risk. The resulting residual risk to soil at the cleanup goal concentrations is 1.5E-04, which is slightly above the acceptable NCP risk range of 1E-04 to 1E-06. While this exceeds the NCP risk range goal, neither the NCP nor MCP requires remediation to below background concentrations. Summary calculations are presented in Table B-17 in Appendix B.

In addition to human health goals, areas in Zone 4 and River Park were identified based on ecological risk to pesticides. The pesticide cleanup levels for Zone 4 Open Space reuse and the River Park are presented in Table 2-8 along with the other human health cleanup goals.

The ecological clean-up levels were used to generate the risk reduction curves (Figures 2-4 through 2-9), to determine the locations recommended for remediation. The curves present the change in the estimated site-wide hazard index because specific sampling locations are successively remediated to a clean-up concentration resulting in a hazard index of 10, and the associated percent risk reduction. Note the clean-up concentration was substituted for a location-specific concentration only when the clean-up concentration was less than the detected concentration. Clean-up concentrations did not replace nondetect data, even if one-half of the SQL was greater than the clean-up concentration.

When the slope of the curve flattens, the risk reduction achieved by remediating the associated locations is lessened. Hence, site locations are recommended for remediation based on the magnitude of risk reduction achieved by their remediation. The locations recommended for remediation of pesticides (from Figures 2-3 to 2-7) based on risks to the short-tailed shrew are 13SS02, 17SOL02, and 15SB02; and 17SB03, 13SS02, 15SB02, and 13SB01, based on risks to the American robin.

Table 2-8

MTL Soil Cleanup Goals for Site Reuse (mg/kg)

Chemical	Zone 1 Commercial Reuse	Zone 1 Residential Reuse	Zone 2 Commercial Reuse	Zone 2 Residential Reuse	Zone 3 Commercial Reuse	Zone 3 Residential Reuse	Zone 4 Residential Reuse	Zone 4 Open Space	River Park
Benzo(a)anthracene	—	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Benzo(a)pyrene	—	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Benzo(b)fluoranthene	—	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Benzo(k)fluoranthene	—	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Chlordane	—	1.5	—	1.5	—	1.5	1.5	1.4	1.4
Chrysene	—	11.1	—	11.1	11.1	11.1	11.1	11.1	11.1
4,4'—DDD	—	—	—	—	—	—	2.5E-01	13.7	13.7
4,4'-DDE	—	3.9E-01	—	—	—	—	3.9E-01	1.4E-01	1.4E-01
4,4'-DDT	—	6.0E-01	—	—	—	—	6.0E-01	1.7E-01	1.7E-01
Dibenz(a,h)anthracene	—	—	—	2.7E-01	—	2.7E-01	2.7E-01	—	2.7E-01
Dieldrin	—	5.6E-02	—	5.6E-02	—	—	5.6E-02	3.5E-01	3.5E-01
Heptachlor epoxide	—	3.5E-01	—	3.5E-01	—	—	3.5E-01	—	—
Indeno(1,2,3-cd)pyrene	—	—	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Aroclor 1260	—	1.0	—	1.0	—	1.0	1.0	1.0	—
Beryllium	—	2.1	—	2.1	—	2.1	2.1	2.1	2.1

Note: The cleanup goals correspond to soil background concentrations with the exception of 4,4'-DDD which is risk-based, and Aroclor 1260 which is regulatory-based. Pesticide cleanup goals for Zone 4 Open Space and River Park are based on ecological risk.

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Table 2-9

Residual Human Health Risk from Soil at Cleanup Concentrations

Chemical	Soil Cleanup Goal (mg/kg)	Residual Carcinogenic Risk to Human Health
Benzo(a)anthracene	8.5	2.6E-05
Benzo(a)pyrene	2.0	5.9E-06
Benzo(b)fluoranthene	7.9	2.4E-05
Benzo(k)fluoranthene	6.2	1.9E-05
Chlordane	1.5	8.2E-07
Chrysene	11.1	3.4E-05
4,4'-DDD	2.5E-01	2.5E-08
4,4'-DDE	3.9E-01	5.4E-08
4,4'-DDT	6.0E-01	8.4E-08
Dieldrin	5.6E-02	3.8E-07
Dibenz(a,h)anthracene	2.7E-01	8.1E-07
Heptachlor epoxide	3.5E-01	1.3E-06
Indeno(1,2,3-cd)pyrene	3.0	9.4E-06
PCB (Aroclor 1260)	1.0	7.5E-06
Beryllium	2.1	1.9E-05
		Total Residual Carcinogenic Risk = 1.5E-04

The removal of metals at locations 14SS03, 12SUB01, 14SUB01, 15SB02, 14SUB02, and 16SS01 will result in a 25% reduction in risk to the shrew via metals exposure (from Figures 2-8 and 2-9). This percent reduction, however, is driven by nickel, which dominates the metals hazard index. Potential toxicity to soil invertebrates will be reduced by the removal of locations 14SUB01, 16SS01, and 14SS01. These locations are recommended for the remediation of metals.

SECTION 3

IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The primary objective of this section is to identify and screen potential remedial technologies so that those technologies retained can be combined into remedial alternatives that protect human health and the environment and encompass a range of appropriate source area cleanup options for MTL. The technology identification and screening process presented includes the results of four general steps:

1. Development of general response actions.

2. Identification and screening of the technologies applicable to each general response action to identify those that cannot be implemented technically at the site.

3. Identification and evaluation of technology process options to select a representative process for each technology type retained for consideration.

4. Identification of volumes or areas to which the general response actions might be applied, while considering the requirements for protectiveness and the chemical and physical characteristics of the site.

Estimates of the areas and/or volumes of contaminated media that may require remediation are presented in Subsection 3.1. General response actions developed to address remedial action objectives are presented in Subsection 3.2. The results of the preliminary screening of remedial technologies and process options for on-site soil are presented in Subsection 3.3. Subsection 3.4 presents the results of the representative process option selection.

3.1 ESTIMATED QUANTITIES OF ON-SITE SOIL FOR REMEDIATION

To evaluate and compare potential remedial alternatives, reasonable estimates of the quantities of soil requiring remediation are needed. Overall, it is not possible to accurately predict the quantities of soil requiring remediation until remedial activities occur and conformational sampling is conducted. However, quantity estimates are necessary to develop and screen remedial alternatives. Soil cleanup goals based on the risk assessment and site background levels are developed in Subsection 2.3 and are summarized in Table 3-1.

An estimate of contaminated soil areas and volumes is necessary to calculate remedial costs in Section 5. The majority of data points indicate that the contamination is limited to depths of 0 to 2 ft. While insufficient sampling was conducted at all areas to truly define an actual depth of contamination, very few sampling points indicated contamination at the deeper soil levels. For the purposes of estimating volumes of soil

Table 3-1

MTL Soil Cleanup Goals for Site Reuse (mg/kg)

Chemical	Zone 1 Commercial Reuse	Zone 1 Residential Reuse	Zone 2 Commercial Reuse	Zone 2 Residential Reuse	Zone 3 Commercial Reuse	Zone 3 Residential Reuse	Zone 4 Residential Reuse	Zone 4 Open Space	River Park
Benzo(a)anthracene	—	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Benzo(a)pyrene	—	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Benzo(b)fluoranthene	—	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Benzo(k)fluoranthene	—	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Chlordane	—	1.5	—	1.5	—	1.5	1.5	1.4	1.4
Chrysene	—	11.1	—	11.1	11.1	11.1	11.1	11.1	11.1
4,4'—DDD	—	—	—	—	—	—	2.5E-01	13.7	13.7
4,4'-DDE	—	3.9E-01	—	—	—	—	3.9E-01	1.4E-01	1.4E-01
4,4'-DDT	—	6.0E-01	—	—	—	—	6.0E-01	1.7E-01	1.7E-01
Dibenz(a,h)anthracene	—	—	—	2.7E-01	—	2.7E-01	2.7E-01	—	2.7E-01
Dieldrin	—	5.6E-02	—	5.6E-02	—	—	5.6E-02	3.5E-01	3.5E-01
Heptachlor epoxide	—	3.5E-01	—	3.5E-01	—	—	3.5E-01	—	—
Indeno(1,2,3-cd)pyrene	—	—	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Aroclor 1260	—	1.0	—	1.0	—	1.0	1.0	1.0	—
Beryllium	—	2.1	—	2.1	—	2.1	2.1	2.1	2.1

Note: The cleanup goals correspond to soil background concentrations with the exception of 4,4'-DDD, which is risk-based, and Aroclor 1260, which is regulatory-based. Pesticide cleanup goals for Zone 4 Open Space and the River Park are based on ecological risk.

for remediation, a conservative average depth for limit of contamination was estimated to be from 0 to 3 ft deep. Unless otherwise noted for a particular area of contamination, the estimated depth of contamination for each area was selected to be at 3 ft. Soil volumes for cleanup were estimated for each of three possible site reuse scenarios based on commercial and residential reuse for the four zones at MTL as defined by the Watertown Arsenal Reuse Committee. The site reuse scenarios are as follows:

Scenario 1 — Commercial reuse for Zones 1, 2, and 3, public access for Zone 4 and River Park.

Scenario 2 — Residential reuse for Zones 1, 2, and 3, public access for Zone 4 and River Park.

Scenario 3 — Commercial reuse for Zones 1 and 2, residential reuse for Zone 3, and public access for Zone 4 and River Park.

The estimated soil volume calculations are summarized in Table B-18 in Appendix B. The estimated areas requiring remediation are presented in Figures 3-1 through 3-3. Table 3-2 summarizes the estimated soil volume for each reuse scenario. Table 3-3 summarizes the estimated individual areas for each reuse scenario and the contaminants present. It should be noted that based on soil concentrations, there is no difference in contaminated soil volumes between commercial reuse and residential reuse for Zone 3. Hence, estimated soil volumes generated for Scenarios 1 and 3 are the same value.

Seven additional on-site areas that might require remediation were not included in the volume estimates. All but one of the areas are located in Zone 2. The last area is located in Zone 4. The first area is underneath Building 311 and the second area is underneath Building 312. Samples from underneath these buildings show PAH contamination above cleanup goals for the zone. These areas will not be remediated because the buildings present a barrier to contact with the contamination. Institutional controls would be required to restrict building activities so that the subsurface soil is not disturbed. Should Building 311 or 312 be removed, the soil beneath the foundations will require remediation.

A third area is located in Zone 2 and deals with metals contamination that may be a risk to ecological receptors. As discussed in Subsection 2.3.3.2, specific sampling points contained metals concentrations above site background that may be an ecological risk. These points were 14SS01, 14SS03, 12SUB01, 14SUB01, 15SB02, 14SUB02, and 16SS01. Points 15SB02 and 16SS01 are included in areas designated for remediation for human health risk. However, the other points listed above are all located between Building 60 and Structure 295 bordering North Beacon Street and are not in an area where human health risk is a concern. Since the metals cleanup goals based on ecological risk (as derived in Subsection 2.3) are considered to be very conservative due to a high level of uncertainty of risk values, it remains unclear if these metals concentrations actually are a risk to ecological receptors. Nevertheless, additional soil

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Table 3-2

Summary of MTL Estimated Soil Volumes for Removal

Reuse Scenario	Site Areas	Soil Volume (yd^3)
Reuse Scenario 1	Zone 2 Zone 3 Zone 4 River Park	7,000 2,250 9,550 3,500 22,300 - Total
Reuse Scenario 2	Zone 2 Zone 3 Zone 4 River Park	12,000 2,250 9,550 3,500 27,300 - Total
Reuse Scenario 3	Zone 2 Zone 3 Zone 4 River Park	7,000 2,250 9,550 3,500 22,300 - Total

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Table 3-3

MTL Estimated Soil Areas for Removal

Reuse Scenario	Location of Soil Areas*		Soil Volume (yd^3)	Contaminants
Reuse Scenario 1	A	Zone 2	1,400	PAHs
	B	Zone 2	1,350	PAHs
	C	Zone 2	750	PAHs
	D	Zone 2	800	PAHs
	E	Zone 2	750	PAHs
	F	Zone 2	1,950	PAHs
	G	Zone 3	450	PAHs
	H	Zone 3	900	PAHs
	I	Zone 3	900	PAHs
	J	Zone 4	1,200	Pesticides, PCBs
	K	Zone 4	4,500	Pesticides
	L	Zone 4	1,950	Pesticides, PCBs
	M	River Park	500	Pesticides, PAHs
	N	River Park	750	Pesticides
	O	River Park	750	PAHs
	P	River Park	1,500	Pesticides, PAHs
			22,300 - Total	
Reuse Scenario 2	A	Zone 2	1,400	Pesticides, PAHs
	B	Zone 2	1,350	Pesticides. PAHs
	C	Zone 2	2,400	Pesticides, PAHs
	D	Zone 2	800	Pesticides, PAHs
	E	Zone 2	300	Pesticides
	F	Zone 2	750	PAHs
	G	Zone 2	1,350	PAHs
	H	Zone 2	800	Pesticides
	I	Zone 2	900	PCBs
	J	Zone 2	1,950	Pesticides, PAHs
	K	Zone 3	600	PAHs
	L	Zone 3	900	PAHs
	M	Zone 3	900	PAHs
	N	Zone 4	1,200	Pesticides, PCBs
	O	Zone 4	6,400	Pesticides
	P	Zone 4	1,950	Pesticides, PCBs
	Q	River Park	500	Pesticides, PAHs
	R	River Park	750	Pesticides
	S	River Park	750	PAHs
	T	River Park	1,500	Pesticides, PAHs
			27,300 - Total	

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Table 3-3

MTL Estimated Soil Areas for Removal (Continued)

Reuse Scenario	Location of Soil Areas*		Soil Volume (yd^3)	Contaminants
Reuse Scenario 3	A	Zone 2	1,400	PAHs
	B	Zone 2	1,350	PAHs
	C	Zone 2	750	PAHs
	D	Zone 2	800	PAHs
	E	Zone 2	750	PAHs
	F	Zone 2	1,950	PAHs
	G	Zone 3	450	PAHs
	H	Zone 3	900	PAHs
	I	Zone 3	900	PAHs
	J	Zone 4	1,200	Pesticides, PCBs
	K	Zone 4	4,500	Pesticides
	L	Zone 4	1,950	Pesticides, PCBs
	M	River Park	500	Pesticides, PAHs
	N	River Park	750	Pesticides
	O	River Park	750	PAHs
	P	River Park	1,500	Pesticides, PAHs
			22,300 - Total	

*Corresponds to calculations in Table B-18 in Appendix B and areas depicted on Figures 3-1 to 3-3.

samples will be collected in this area to confirm the presence of potentially elevated levels of metals. If these levels are confirmed, a localized soil excavation and removal for metals will be performed.

The remaining four areas are where localized "hot spots" for lead were detected. One area is located near Building 656, where a localized "hot spot" for lead was detected at sampling point Boring 05SB-2 (7160 mg/kg). A second area is located outside Building 311 near Arsenal Street at sampling point 02SS-2 (1120 mg/kg). The third area is located outside Building 43 near Arsenal Street at sampling point 03SS-2 (1530 mg/kg). The last area is located in the western portion of the River Park at sampling point GRSB-11 (1330 mg/kg). According to the risk assessment, while lead is not a contaminant of concern sitewide, these hot spots would provide a localized risk. This localized risk is based on exceedances of the EPA default lead cleanup goal in soil for human health. For a full discussion of site lead levels, see Subsection 1.2.4.3.2. As part of the remedial activities, these areas will be sampled and analyzed to confirm the presence of high lead levels. If high lead levels are confirmed, the areas will be included for remediation. The localized lead contamination will be excavated and the soil transported off-site for disposal.

It should be noted that the above soil estimates are used for cost estimating purposes. During actual remediation, if soil is to be removed, field screening instruments will be used to qualitatively determine when cleanup goals have been achieved. When it is believed that the goals have been met, confirmatory soil sampling would be performed in the excavation at the base and along the side walls. If laboratory analysis confirms that cleanup goals have been achieved, no additional excavation will take place. If the laboratory analysis shows that contaminant levels are greater than cleanup goals, excavation will continue until cleanup goals are achieved or until a previously designated maximum depth has been reached. For site areas other than Zone 4 and the River Park, the designated maximum depth is 10 ft. In the unlikely event that contamination persists beyond 10 ft, excavation will be ceased at 10 ft since acceptable risk reduction would have been achieved. Should future site development occur, building foundation excavation would not extend beyond 10 ft, so there is no foreseeable risk exposure pathway. Also, at a maximum depth of 10 ft, groundwater would not be encountered during excavation. In Zone 4 and the River Park, there is a possibility that at high groundwater conditions, groundwater may be encountered prior to the 10-ft depth. Groundwater may be as shallow as 5 ft deep. However, in Zone 4 and the River Park, there will be no future building development and there is no risk to deep soils. Therefore, in Zone 4 and the River Park, excavation will cease at a maximum depth of 10 ft or at the groundwater table, whichever is encountered first. If deemed necessary by EPA or MADEP, deed restrictions may be enacted for any residual contamination left in place below the maximum excavation depths; however, the Army does not think these measures will be necessary.

3.2 GENERAL RESPONSE ACTIONS

General response actions describe, in general terms, remedial actions that satisfy the remedial action objectives. For each general response action, more than one remedial technology may be applicable. Remedial technologies are discussed in Subsection 3.3.

The general response actions identified for on-site contaminated soils are intended to address the risk to human health and the environment resulting from direct or indirect exposure to the contaminants. The general response actions are:

- No action/institutional controls.
- Containment of contaminated soil.
- Removal of contaminated soil.
- Treatment/disposal of contaminated soil.

3.3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Remedial action technologies must perform the general response action identified for the specific medium and must satisfy the remedial response objectives. Technology types refer to general categories of technologies, such as chemical treatment, thermal destruction, or capping. Technology process options are specific processes within each technology type. Numerous technology process options may exist within a specific technology type. Process options may be similar in action, or may be quite different in the manner in which they accomplish similar results.

A wide range of potentially applicable treatment technologies and process options was reviewed and selectively reduced by screening the technologies and process options with respect to technical implementability while considering site-specific conditions, a specific medium of concern, and existing contaminants. The initial list of technologies was developed based on available information from other sites, and on a review of technical publications, conference proceedings, EPA publications, and current vendor information. The technologies retained after this screening are used to develop remedial action alternatives (see Section 4).

Remedial technologies and process options were identified and screened using the following process:

- The technology process option was described along with a discussion of its potential application.

- The technical reliability (technology development, performance, and safety) and implementability of the process option to site and waste characteristics were evaluated.

- A recommendation was then made to retain or eliminate the process option from further consideration based on the criteria previously described.

Soil remediation strategies are principally intended to reduce risk to human health and the environment from exposure to contaminants. The following soil remediation technologies were evaluated:

Response Action	Technology
No action	No action
Institutional actions	Monitoring Access/use restrictions
Containment	Capping Diversion
Removal	Excavation
Treatment	In situ treatment Thermal treatment Biological treatment Physical treatment Chemical treatment
Disposal	On-site disposal Off-site disposal

The results of the technology screening for soil are highlighted in Figure 3-4 and are discussed in the following subsections.

It should be noted that this technology screening does not specifically address technologies that treat metals. From the human health risk assessment, only one metal (beryllium) was a contaminant of concern; however, based on site cleanup goals and on-site concentrations, no site areas have been identified as requiring remediation for beryllium. While there are potential areas involving metals contamination, there is insufficient volume to warrant any particular treatment technologies for such metals. It is unclear whether any areas with potential metals contamination (either lead for human health or metals based on ecological risk) actually have concentrations significant enough to pose a risk. These areas will first be sampled to confirm the presence of metals. However, even if metals remediation is necessary, the volume of metals-contaminated soil would be too small to warrant any specialized treatment technology. Hence, no metals treatment technologies are included. Since the volume of metals-contaminated soil would not be in significantly large quantities to warrant specific metals removal technologies, all such soil would be excavated and transported off-site for disposal, or reused on-site as deep fill (greater than 2 foot depth) where ecological risks are no longer a concern.

3.3.1 NO ACTION

Description — Under the no action option, no remedial measures would be implemented.

Areas of the Site — This technology is applicable to all areas of the site.

Technical Considerations — This technology requires no implementation.

Other Considerations — Future residents and workers would potentially be allowed access to potentially contaminated areas of the site once the facility has been decommissioned.

Recommendations — The no action option will be considered further as a baseline comparison with other alternatives as required by the NCP.

3.3.2 INSTITUTIONAL ACTIONS

Description — Institutional actions to be considered for this site include restricting access to the site and contaminants, deed restrictions, and monitoring. Access restrictions may include site security by maintaining a security fence around the site, which would restrict possible direct contact of humans with the contaminated areas. The security upgrade would also include ensuring that locked well housings are maintained around all monitor wells. Deed restrictions would be imposed on areas of the site determined to be contaminated with hazardous substances. These restrictions would ban the use of these areas for the production of agricultural goods intended for consumption. Restrictions imposed on these areas would also limit their future use to nonresidential applications and would ban the use of groundwater in the vicinity of the entire site for domestic purposes. A Statement of Condition (SOC), delineating contaminated or hazardous areas on-site, would be required prior to any real estate transaction involving the transfer of any portions of the site.

Remedial response actions could then be implemented in the event contaminant sources further threaten public health and/or the environment.

Areas of the Site — This technology is applicable to all areas of the site.

Technical Considerations — This technology can be easily implemented with conventional construction and sampling techniques.

Other Considerations — Institutional action with upgraded security will restrict access to contaminated on-site areas and establish a measure of human health although ecological risk would remain. This technology has few associated capital costs and comparatively nominal operations and maintenance (O&M) costs.

Recommendations — This technology will be retained for further consideration.

3.3.3 CONTAINMENT TECHNOLOGIES

Containment technologies considered for the MTL outdoor areas would be designed to prevent direct contact with contaminated soils. Many containment technologies can be

easily implemented with proven construction techniques, depending on the materials used and the specific site characteristics.

The following containment process options were considered and are discussed in more detail in the following subsections:

- Caps.
- Runon/runoff controls.

3.3.3.1 Capping Techniques

Description — Capping techniques are traditionally designed to minimize infiltration of precipitation through contaminated soils and thereby reduce generation of leachate and/or contaminant transport to groundwater. They also prevent direct contact with contaminated soils, which is the primary objective of soil remediation at the MTL site. Capping can be accomplished with a wide variety of materials. These various materials and techniques are screened in more detail in the following paragraphs, according to the following classes:

- Synthetic membranes.
- Low-permeability soils.
- Soil admixtures (surface sealing).
- Asphalt or concrete (surface sealing).
- RCRA-type multilayer cover system.

Synthetic Membranes — Use of synthetic membranes as capping materials includes those made of polyvinyl chloride (PVC); chlorinated polyethylene; high-, medium-, or low-density polyethylene (HDPE, MDPE, and LDPE); or rubber.

Major factors associated with the successful use of synthetic membranes are selection of the proper membrane material for the desired application, proper seaming and placement to prevent tearing, and protection against weathering and root penetration. The synthetic membranes have highly desirable characteristics such as extremely low permeabilities and are readily available. This type of membrane would provide a physical barrier preventing direct contact with contaminated soil. The major limitation of synthetic membranes is their potential for failure due to puncturing, tearing, or weathering, which might affect their long-term integrity. Regrading the area to be capped to promote positive drainage is required prior to cap installation.

A cap would not need to be constructed in the existing building areas because these structures already provide a physical barrier to prevent contact with contaminated soil. There could be problems with the integrity of this type of cap in traffic areas at the site; however, synthetic caps are typically covered with soil, and if so, the cover can be designed to carry traffic without injury to the cap.

Synthetic membranes are used in some applications because they may offer substantial cost benefits over other materials, i.e., low-permeability soils and soil admixtures. This

is particularly true where adequate local supplies of suitable low-permeability soils are unavailable.

Low-Permeability Soils — The term "low-permeability soils" refers to clays and other fine-grained soils that, when compacted, consistently maintain an in situ permeability of 10^{-6}cm/sec (RCRA definition of low permeability, 0.1 ft/yr) or less. Low-permeability soils must be of adequate strength to maintain the cap system's integrity and performance in terms of stability and permeability. The technology is implemented by preparing the site to achieve proper grades and then placing the compacted, low-permeability soil cover over the graded surface. The cap can then be covered by a clean soil layer, followed by topsoil and revegetation.

A key advantage to using compacted low-permeability soils is that they are a natural material (materials that are adapted and/or have long-term existence in the local environment) and may be considered more durable in the long term. In addition, no joint seaming is required. Clay and low-permeability soils of adequate clay content are to some extent "self-healing" and can be repaired through placement of additional clay/soil if damage occurs.

Cap integrity and maintenance problems in traffic areas on-site could be significant concerns.

Soil Admixtures — A low-permeability soil admixture can be placed as the cap layer in a multilayer cover system or a single-layer cap system similar to a clay cap. Soil and bentonite admixtures are most commonly used and incorporate a combination of natural and processed bentonite.

These admixtures can replace a natural low-permeability soil (i.e., clay) layer when appropriate native soil deposits are not available or cannot be used cost-effectively. Soil/fly ash/lime or soil/fly ash/lime/kiln dust admixtures may be used as alternatives to soil and bentonite admixtures. The process typically involves a geotechnical assessment of available soils and determination of the optimal mixture. The bentonite is placed and admixed with the soils, and the mixture is uniformly spread and compacted. The bentonite, after proper hydration, expands to fill the void spaces within the soil layer.

Soil and bentonite admixtures are gaining acceptance in field construction applications. Because clay is not always readily available locally, there are several processed bentonite products being marketed; some contain additives to reduce the potential for chemical attack by contaminated materials. Soil admixtures require special installation procedures because of the mixing of materials required before installation of the cap. In addition, the soil and bentonite layer would require a granular soil cover that would be regraded prior to cap construction. This would promote drainage and minimize direct contact of the soil and bentonite mixture with the contaminated materials.

Because of the special installation procedures, soil admixtures may be costlier than alternative materials. In addition, low-permeability natural soils should be readily available in this location and would be equally effective and less costly.

Asphalt or Concrete — Asphalt or concrete can be used on a surface as an obvious physical barrier between humans and the contaminated soil below and as an effective means to control surface infiltration and soil erosion. This technology employs conventional construction techniques.

Though an effective concrete cap can be engineered, difficulties associated with the placement and maintenance of a concrete cap can reduce its efficiency. Long-term effects of property use, differential settlement, sun aging, weathering, creep and subgrade movements, expansion cracking, and possible freeze/thaw damage could combine to reduce the effectiveness and damage the integrity of the asphalt or concrete cap. Concrete is a proven construction material; however, in this application, any types of cracks or injury to the concrete could result in failure of the material as an effective cap. It is anticipated that there would be long-term maintenance required for a concrete cap; however, asphalt would also be very effective as a cap material and would be easier and less expensive to maintain than concrete.

The asphalt cap for this application would consist of an asphalt parking lot over specified soil areas. Conventional design and construction methods would be employed to create an asphalt surface suitable for light duty equivalent to parking lots and driveways. The surface would be prepared by excavating the top 6 inches (to remove grass and roots). This excavated material would be properly disposed off-site. The remaining soils would be compacted before the cap is placed. A typical cap would consist of a layer of clean soil, a subbase (i.e., crushed stone), an asphalt base course, and an asphalt driving surface (i.e., pavement). The thickness of each layer would be determined during design based on the resilient modulus of the site soils, assumed traffic duty, and preferences for materials of construction.

RCRA-type Multilayer System — The multilayer cap system represents a cover technology that is gaining widespread use as an infiltration control strategy for waste containment or in-place closure. A typical multilayer cap system consists of the following three layers:

- Upper soil layer — A topsoil and native soil layer, typically placed to a thickness of approximately 12 to 24 inches. This layer serves to support vegetation, provide a cover for the drain layer, divert surface runoff, and offer partial freeze/thaw protection to the underlying cap layer.

- Middle drain layer — A graded layer of porous flow-zone material (i.e., sand or gravel) or a geogrid that acts as a drainage medium. A sand or gravel layer is typically placed to a thickness of approximately 18 inches.

- Cap layer — A compacted layer of fine-grained soils of low permeability designed to divert infiltration that has percolated through the upper soil

layer. This cap layer is typically placed to a thickness of approximately 18 to 24 inches.

There are several advantages of the multilayer cover system compared to standard native soil cover, including:

- A drain layer that diverts additional percolating water so that it does not eventually contact the underlying contaminated soils.

- Minimized slumping of the topsoil and upper soil layers in steeper slope areas.

Multilayer cover systems can typically divert greater than 90% of the precipitation falling on a site. A long-term, effective solution could be expected because the cover is constructed of natural materials.

For reasons previously described for other cover systems, problems may be encountered with placing a complete, effective multilayer cover if buildings remain in place. The cover would be 5 ft thick and might not be practical unless the buildings were demolished. There could also be problems with the long-term integrity of the cap in the high-traffic areas of the site.

Areas of the Site — Capping techniques are potentially directly applicable to all contaminated soil areas.

Technical Considerations — Generally, capping technologies can be implemented with proven construction techniques, depending on the materials used and the site characteristics. Regrading the area to be capped is required to promote drainage prior to cap installation. There could be problems associated with maintaining the cap in areas where activity would continue on-site. Regardless of the type of cap, maintenance requirements are very similar. The cap should be inspected on a regular basis for signs of erosion, settlement, or subsidence. Inspections should be most frequent during the first 6 months after installation as most problems are likely to appear during this period. Any signs of unexpected settling or subsidence should be addressed by removing the overburden to inspect and repair the affected area. Maintenance of the cap should be limited to periodic mowing of the vegetative layer to prevent invasion by deep-rooted vegetation and burrowing animals. For the asphalt or concrete cap, there is no maintenance for mowing; however, continued inspections should be made for surface cracking. In high-traffic areas, a concrete or asphalt cap would be strongly preferred.

Other Considerations — Capping will facilitate a measure of human health and environmental protection by restricting direct contact of humans or wildlife with contaminated soils. The use of an asphalt or concrete cap would prevent the cultivation of agricultural products in areas of contaminated soils. Capping systems are traditionally designed to minimize surface water infiltration; however, capping at MTL would be designed instead to serve as a physical barrier preventing contact with

contaminated soils. A cap at MTL would not need to prevent stormwater infiltration; therefore, a cap at MTL would not be required to meet all RCRA performance standards. There are no apparent institutional obstacles to capping. The costs for capping differ widely, depending on materials (type and availability) and design parameters (to reflect site-specific characteristics). O&M costs involve long-term inspection and maintenance of the cap system to ensure integrity. Capping is typically used in conjunction with other grading, revegetation, and drainage control technologies. Since contaminated soil would remain in place, deed restrictions would be necessary for the capped areas to prevent future development or reuse activities that might lessen the cap integrity. No excavation would be permitted in capped areas.

Recommendations — Since the primary remedial goal for the soils is to prevent humans from contacting contaminated soils, the cap need only provide a physical barrier between the soil and humans. In addition, the cap should inhibit any vegetation from becoming rooted beneath the cap in the contaminated soil since this could provide a secondary route of exposure if the vegetation were consumed. The cap must also be able to withstand traffic, create a seal with existing building foundations, and be relatively inexpensive to maintain; therefore, synthetic membrane caps will not be retained for further consideration since they can be punctured relatively easily and could not withstand the heavy traffic anticipated with future site reuse.

Low-permeability soil and soil admixture cap systems will not be retained for further consideration because they are not compatible with heavy-traffic areas and also because they may not prevent vegetation from rooting in the underlying soils.

RCRA-type multilayer caps will not be retained for further consideration since they require extensive maintenance, are not compatible with heavy traffic, could interfere with site reuse, and are relatively expensive to install. At MTL, where a cap needs only to be a simple physical barrier, a RCRA-type multilayer cap would be excessive and wasteful since it is designed for an entirely different purpose (i.e., to prevent infiltration).

Asphalt or concrete caps are resistant to heavy traffic and will prevent vegetation from rooting in the contaminated soil; however, concrete caps are much more expensive and less resistant to freeze/thaw cracking than asphalt caps. Therefore, only asphalt caps will be retained for further consideration as a capping alternative.

3.3.3.2 Runon/Runoff Controls

Description — In general, runon/runoff control measures use surface management controls to divert surface water runon, direct and collect surface water runoff, and minimize potential erosion and sediment transport. Runon/runoff controls include diversion ditches, dikes, and berms.

Areas of the Site — These measures are potentially applicable to all contaminated soil areas.

Technical Considerations — These controls use common engineering and construction practices and would be constructed around caps, excavations, or surface contamination to manage surface water runon/runoff and minimize erosion. Maintenance and repair of these diversion controls would be necessary to maintain optimum performance. Temporary runon/runoff controls may also be constructed during implementation of other technologies.

Recommendations — This process option will be retained for further consideration.

3.3.4 REMOVAL OF CONTAMINATED SOILS

Description — Removal technologies involve conventional excavation procedures to remove contaminated materials from site areas. At the MTL site, the maximum volume of material requiring excavation is dependent on the recommended cleanup level. This technology is considered as a remedial activity only in conjunction with off-site disposal and/or treatment technologies.

Areas of the Site — This technology can be applied to all problem areas of the site that include contaminated surface soils and subsurface soils.

Technical Considerations — Excavation can be accomplished with commonly used construction equipment and techniques. The depth of planned excavation would be shallow enough to avoid encountering the water table, so no provisions for excavation dewatering would be needed. Stockpiles would require proper containment, such as covering with a plastic liner until transport for treatment or disposal. Air monitoring would be necessary during excavation activities.

Other Considerations — A major advantage of this technology is that the source of contamination will be removed (to cleanup levels). Removal of the contaminant source will benefit the local environment in the long term and minimize potential threats to public health emanating from the site. However, if this material is transferred to another site without prior treatment, future liability problems could result.

There are some restraints on complete removal. Because of the large surface area under consideration, excavation activities would require careful management and may result in surface runoff that requires monitoring, collection, and sediment control measures. In addition, surface runoff must meet the state water quality standards. Dust control during excavation may also be necessary. Care must also be maintained so as not to disturb underground utilities or conduits; this is not anticipated to be a problem at MTL.

Once removed, the soil would require treatment on-site or transportation off-site for treatment or disposal. Any off-site transportation of contaminated soil would have to be in compliance with applicable transportation requirements. Off-site transportation also has the potential risk of a release during transport (e.g., traffic accident).

Recommendations — Removal of contaminated soils will be retained for further consideration.

3.3.5 TREATMENT TECHNOLOGIES

Treatment technologies include thermal, biological, chemical, or physical processes to degrade, remove, destroy, or immobilize contaminants. These technologies can be divided into those that are conducted in situ and those that require removal of the contaminated medium. In situ treatment process options include:

- Bioreclamation/biodegradation.
- Supercritical extraction.
- Soil vapor extraction (SVE).
- Electromagnetic (EM) heating with SVE.
- In situ vitrification.
- Soil flushing.
- In situ stabilization.

Ex situ treatment technology process options require excavation of contaminated soils prior to implementation. These treatment technology process options for soils include:

- Thermal
  - Incineration
  - Low-temperature thermal treatment.
- Physical
  - Soil washing
  - Solvent extraction
  - Solidification/stabilization
  - Macroencapsulation/overpacking.
- Chemical
  - Chemical oxidation
  - Chemical dechlorination.
- Biological
  - Landfarming/composting
  - Bioreactors.

More detailed discussions of these process options are presented in the following subsections.

3.3.5.1 In Situ Treatment Options

3.3.5.1.1 Bioreclamation/Biodegradation

Description — In situ biological treatment, also referred to as bioreclamation or biodegradation, is a technique for treating contaminated soils in place by microbial degradation. This is accomplished by the addition of oxygen and nutrients to soil to enhance the natural biodegradation of organic compounds by microorganisms, resulting

in the breakdown and detoxification of the organic contaminants. These microorganisms can be either naturally occurring, specially adapted, or genetically engineered. Oxygen and nutrients are delivered to the soils through injection wells or an infiltration system.

Areas of the Site — This technology can potentially be applied to treatment and decontamination of surface soils and subsurface soils.

Technical Considerations — Review of the literature indicates that bioreclamation has been successfully used in tests on materials contaminated with SVOCs; however, bioreclamation is sensitive to a number of environmental factors, including availability of trace nutrients, oxygen concentration, redox potential, pH, degree of water saturation, and temperature. These factors would have to be monitored and controlled during operation.

Laboratory and/or pilot-scale tests would be required to confirm the feasibility of bioreclamation at the site and/or to determine design and operating parameters; however, it is anticipated that there may be problems associated with in situ biological treatment because of the low soil permeabilities. It is also unlikely that this technology could achieve background levels without extensive treatment.

Other Considerations — Contaminants could be mobilized into the groundwater during treatment. If this results in these contaminants migrating to the Charles River, the groundwater pathway could become a risk, where currently it is not considered a risk. Groundwater controls and possibly surface controls could be required for this technology.

Recommendations — In situ bioreclamation will not be retained for further consideration because of the low permeabilities of the subsurface soils at MTL and the necessity of achieving background for cleanup goals.

3.3.5.1.2 Supercritical Extraction

Description — This process is an extraction method using steam at temperatures and pressures beyond its critical point. The fluid exhibits altered solvent properties that allow the dissolution and/or volatilization of organic contaminants, which can make extraction more rapid and efficient than conventional extraction methods.

The steam or other heated fluid is injected and mixed into the ground through specially adapted hollow-core drill stems. Volatilized or dissolved compounds rise to the surface through the soil matrix and are collected by means of a blower system. The collected gases are treated to condense and remove the contaminants using processes such as gravity separation or adsorption on activated carbon. Once treated, the fluids are reheated and reinjected. If successful, this technology allows for a high degree of contaminants to be removed in a relatively short time.

Areas of the Site — This technology can potentially be applied to the subsurface soils.

<u>**Technical Considerations**</u> — This technology is applicable to VOC- and SVOC-contaminated soils. This technology requires a high-permeability soil for effectiveness, but is more applicable for deep contamination than for surface contamination. The high water table at this site would limit the effectiveness of this process option. In addition, there is little subsurface contamination (greater than 4 ft deep) that has been identified by the RI.

<u>**Recommendations**</u> — This process option will not be retained for further analysis because of its limited application potential.

3.3.5.1.3 Soil Vapor Extraction (SVE)

<u>**Description**</u> — SVE, or soil venting, is an established technology for in situ soil treatment. SVE is primarily applicable to treatment of unsaturated, VOC-contaminated soils. SVE treatment removes VOCs, such as TCE and PCE, which are present in some soils at MTL, from the soil by mechanically drawing air through the soil pore spaces. VOCs volatilize into the air as the air moves through the soil. The VOC-laden air is vented to the atmosphere or treated, depending on the amount and types of contaminants present.

SVE is accomplished by installing an array of vents in the contaminated portion of the unsaturated (vadose) zone. These vents are essentially wells that are screened in the vadose zone. The vents are manifolded to the suction side of air blowers, creating a negative pressure in the vents and thus causing air to flow from the soil. Each vent is valved and can be adjusted to the desired flow rate. Using these valves, an SVE system has the flexibility to withdraw air from the most contaminated areas (thereby maximizing the mass removal rate) or to operate at a lower mass emission rate as may be required by the emissions treatment system.

VOCs are released from the soil matrix into the air being drawn through the soil toward the vents and are discharged through the blower. Depending upon the concentration of the VOCs in the air, emissions controls may be required. Vapor-phase carbon treatment of the airstream is a common emissions control technology, particularly for chlorinated solvent contaminants.

<u>**Areas of the Site**</u> — This technology can potentially be applied to subsurface soils.

<u>**Technical Considerations**</u> — This technology would involve the installation of a number of "well vents" across the site, which must be manifolded to air blowers and subsequently an emission control system. Such a setup may prove to be an impediment to present facility operations, as it would involve construction of a number of structures on the site near high-activity areas.

<u>**Other Considerations**</u> — To operate efficiently, the unsaturated soil must have a permeability that is sufficient to allow air movement through the soil. Porous soils are ideal for SVE remedial treatment, although contaminant removal has been established in silty clay soils when high vacuum pressures were applied (Metzer et al., 1987). The

natural soils at the MTL site exhibit low permeabilities and typically appear to be silty clay with some fine sand.

This technology is not proven for removing VOCs from saturated soil conditions, and because of the shallow water table, the vadose zone soils are limited in extent. Finally, areas containing less volatile PAHs, pesticides, and PCBs would still be contaminated after SVE treatment since the SVE system is only effective for removing VOCs.

Recommendations — This technology will not be considered any further as it cannot address the site contaminants requiring remediation (PAHs, pesticides, and PCBs).

3.3.5.1.4 Electromagnetic Heating With SVE (EM/SVE)

Description — The EM/SVE process is based on in situ heating of contaminated material to volatilize hazardous chemicals using EM energy. The volatilized chemicals are recovered using a vapor collection system as described in Subsection 3.3.4.1.3, condensed, and treated or released into the atmosphere.

The EM/SVE process calls for drilling electrode wells to confine an area using metal pipes as electrodes. The material confined to this region is heated, using EM energy, to approximately 90 to 100 °C. Evaporation of part of the groundwater results in steam stripping of the waste area and volatilization of the hazardous compounds. The steam and other volatilized organics are recovered through soil vents. The vapors are condensed, and noncondensables are treated, if necessary, through carbon adsorption prior to venting to the atmosphere. This process can address a wider range of organic constituents than regular SVE because vapor pressures are raised by heating the soil.

Areas of the Site — This technology can potentially be applied to subsurface soils.

Technical Consideration — As with SVE, a number of well vents would be installed across the site, which must be manifolded to air blowers and subsequently to an emission control system.

Other Considerations — As discussed previously, SVE is not retained for further consideration because of the lack of applicability with site contaminants. EM/SVE does not overcome any of these difficulties. EM/SVE is designed to enhance the removal of a standard SVE system, assuming the SVE system can be implemented.

Recommendations — This process option will not be retained for further consideration for the same reasons that SVE was not retained.

3.3.5.1.5 In Situ Vitrification

Description — In situ vitrification is a thermal treatment technology that uses radiofrequency electrodes that are placed in the ground surface. Organic contaminants are treated by vaporization or are pyrolyzed when an electric current is passed through

the electrodes. Inorganics and other remaining contaminants are immobilized as the soil is converted to a molten mass and hardens into a stable glass upon cooling.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — In situ vitrification is a developing technology that has been tested to treat soils contaminated with radioactive materials. Large-scale testing has been done (400 to 800 tons of vitrified mass) and has included treatment of soils contaminated with metals, PCBs, and organics associated with electroplating wastes. An electrical power source is required on-site to supply current for the electrodes. Pilot testing would be required to confirm the technical feasibility and/or to determine the design and operating parameters of this technology.

Other Considerations — The leachability of the contaminants that remain immobilized in the vitrified mass is expected to be negligible. In addition, in consideration of local environmental impacts, off-gases generated during the process are captured in a hood. Operating costs associated with this technology would be relatively high because of the high power requirements. Capital costs can also be high because the electrodes are left in the ground and become part of the glassified mass.

Recommendations — In situ vitrification will not be retained for further consideration because of high costs and future land-use considerations.

3.3.5.1.6 Soil Flushing

Description — The in situ chemical treatment potentially applicable to the MTL site is soil flushing. This technology refers to methods that mobilize and extract contaminants from soils.

Soil flushing is accomplished by use of water or an aqueous chemical solution (i.e., water/surfactants or water/solvents) applied to the area of contamination and then extracted for removal, recirculation, or on-site treatment and reinjection. This is usually accomplished by constructing infiltration galleries, injection wells, or other delivery methods, and using groundwater extraction wells or interception trenches. The soil flushing system can be designed to function as an in situ bioreclamation system after flushing has removed the majority of contaminants from the subsurface soils.

Areas of the Site — This technology can potentially be applied to the subsurface soils and surface soils.

Technical Considerations — Site-specific conditions such as soil type and chemistry dictate the operation and efficiency of this technology. The areas on-site with high proportions of sandy soils present favorable conditions for this technology; however, the most permeable soils at MTL are near the surface and consist of glacial outwash.

Drawbacks of these processes include the channeling of treatment solution through soils and the relatively low permeabilities of the site soils and the hydraulic characteristics, as previously discussed. As a result of these conditions, a large number of cycled pore volumes of treatment solution would be required for treatment. Recent technological advances have led to commercially available flushing methods that use different types of solutions (i.e., polymers) to form a front that drives contamination from adhered soils with a minimum of channeling. Channeling is minimized by flushing with solutions that approximate the density of the contaminants. Such a scheme would reduce treatment time and expense and increase the effectiveness of the treatment scheme.

A further disadvantage of this technology is that the elutriate stream (washing fluid) requires treatment and disposal; therefore, treatment of large amounts of soil requires treatment of large volumes of washing fluid.

Laboratory and/or pilot-scale testing would be required to confirm the technical feasibility and performance and/or to determine the optimum flushing process design and operating parameters for the MTL site.

Other Considerations — Potential risks associated with soil flushing systems include contamination of soil and groundwater outside the treatment zone from the washing fluids (use of additives that are biodegradable may prevent this potential contamination) and mobilization of contaminants into the surrounding environment (hydraulic barriers must be maintained). In addition, some in situ soil flushing processes may be of proprietary status.

Recommendations — This technology will not be retained for further consideration because of the low permeability exhibited by the subsurface soils at MTL.

3.3.5.1.7 In Situ Stabilization

Description — In situ stabilization immobilizes organic and inorganic compounds by using additives that react with the soils and sludges to produce a cement-like mass. The two basic components of the system are the mixing system capable of delivering and mixing chemicals with the soil in situ and the facility that supplies the treatment additives, such as lime, fly ash, or cement.

Areas of the Site — This process option is potentially applicable to site soils.

Technical Considerations — Stabilization has been effective for the immobilization of metals, but results for stabilization of PCBs and organics are not well-documented. Drawbacks to the system are that contaminants are immobilized and are not destroyed, the volume of the contaminated material can increase significantly, and there is potential degradation of the stabilized material from freeze/thaw cycles. Treatability testing would be required to determine the effectiveness of stabilization on soils at MTL.

Recommendations — This process is not recommended for further consideration because it is unproven for PCB- and organic-contaminated soils and the stabilization of the shallow contamination at the site would be highly susceptible to freeze/thaw degradation.

3.3.5.2 Thermal Treatment Options for Excavated Soils

3.3.5.2.1 Incineration

Description — With treatment by incineration, materials contaminated with organics are destroyed by controlled combustion under net oxidizing conditions. The products of incineration generally include CO_2, H_2O vapor, SO_2, NO_x, HCl gases, and ash. Incineration can be used to destroy organic contaminants in liquid, gaseous, and solid wastes.

Methods potentially applicable to the MTL site include rotary kiln, fluidized bed incineration, and innovative infrared technique. Rotary kiln incinerators use a rotary kiln as the primary furnace configuration for combustion. Fluidized bed incinerators (and circulating bed combustors) are refractory-lined vessels containing a bed of inert granular material (i.e., silica sand) that is heated by combustion air. The waste materials are burned when they contact the hot bed material. Infrared incinerators subject waste materials to intense infrared radiation, which causes combustion of waste with a minimum of particulate-producing turbulence.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils. Treatment of all soils by incineration may not be practical, depending on the volumes and concentrations of organics [which affect the British thermal unit (BTU) value] in the soil.

Technical Considerations — Most incineration technologies are well-developed and proven. Rotary kiln incinerators are commercially available and in wide use. Fluidized bed incinerators and infrared systems are available commercially but are not widely used commercially for hazardous waste treatment. Gaseous and aqueous emissions require pollution control devices.

Incinerators are capable of accepting all matrices of organic wastes; however, oversized pieces of material must be reduced before being fed into the fluidized bed, rotary kiln, and infrared incinerators.

Incineration is potentially applicable; if used, it is anticipated that high temperatures (1,300 to 3,000 °F) may be necessary due to the PCB-contaminated soils at MTL. Other soil contaminants at MTL would also be successfully treated by incineration. This technology could be applied either on-site using a mobile rotary kiln incinerator, or off-site at an established waste incinerator.

Recommendations — Incineration will be retained for further consideration because it is potentially applicable to the contaminated soils at MTL.

3.3.5.2.2 Low-Temperature Thermal Treatment

Description — Low-temperature thermal treatment processes have been successfully used to remove organic compounds (primarily VOCs) from contaminated soils by thermal desorption. Soils are uniformly heated to temperatures from 450 to 1,200 °F for the removal of VOCs and PAHs. Temperatures of 1,000 °F or more may be required for sufficient removal of PAHs, PCBs, and pesticides. The volatilized emissions can be either destroyed by a secondary high-temperature combustor, adsorbed onto activated carbon, or condensed and sent off-site for treatment/disposal. Treated soils are typically returned to their origin.

Areas of the Site — This technology can potentially be applied to treatment and decontamination of surface soils and subsurface soils.

Technical Considerations — Low-temperature thermal treatment is a technology that has been proven effective on full-scale soil treatment operations; however, bench-scale studies treating contaminated soil from MTL would need to be performed to predict the efficiency and temperature at which a full-scale treatment unit would be operated. Treated soil could be used as backfill, thus saving costs on disposal of contaminated soil as well as replacement backfill. While no permits would be necessary for remedial actions at a Superfund site, the substantive portions of permit requirements must be met.

Other Considerations — Although this technology would be effective on soils contaminated with the contaminants of concern at MTL (PCBs, pesticides, and PAHs), the higher range of temperatures required for thermal desorption may not be cost-effective compared to incineration.

Recommendations — This technology will be retained for further consideration since it will potentially treat the soil contaminants of concern at MTL.

3.3.5.3 Physical Treatment Options for Excavated Soils

3.3.5.3.1 Soil Washing

Description — Soil washing techniques are similar to in situ soil flushing techniques with the exception that the contaminated soils and other materials are excavated and are treated on-site. This technology refers to methods for removing contaminants by use of a water or aqueous chemical solution (i.e., water/surfactants) applied to the contaminated material after it has been removed from the source area and staged on a concrete or asphalt containment pad. Treatment is usually performed using a multistaged batch process.

A general process scheme for chemical extraction/soil washing involves the following steps (EPA, 1990):

- The soil to be cleaned is pretreated to remove large objects such as pieces of wood, vegetation, concrete, stones, drums, etc., while hard clots of soil are reduced in size. The sieved residue may be cleaned separately.

- The pretreated soil is mixed intensively with an extracting agent. The primary purpose of this step is to transfer the contaminants to the extraction fluid, either as particles or as a solute.

- The soil and the extracting agent are separated. The contaminants, the smaller soil particles (clay and silt particles), and the soluble components in the soil are generally carried off with the extraction agent.

- The soil undergoes subsequent washing with clean extracting agent and/or water to remove as much of the remaining extraction fluid as possible.

- The larger particles carried off with the extraction phase are separated, and if required, these particles undergo a subsequent washing with clean extracting agent.

- The contaminated fine-grained material and the soluble components are separated from the extraction fluid, whereupon part of the fluid is reused after the addition of chemicals, if required.

The chemical extraction/soil washing process results in the transfer of contaminants from the soil matrix to the wash medium. The contaminants may still be absorbed on the clays suspended in the wash medium. The wash medium then undergoes further treatment before final disposal or regeneration. A large number of physical, chemical, and biological purification methods, including coagulation, flocculation, sedimentation, anaerobic and aerobic biological treatment, and immobilization, are available to clean the contaminated aqueous extracting agents.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — Solutions that have potential use at the MTL site include water/surfactant and water/organic solvent/surfactant solutions. These solutions would be best suited for removing the SVOCs, PCBs, and other constituents of concern from the contaminated materials. The soil washing technology has been proven effective at removing the soil contaminants of concern at MTL through numerous laboratory, pilot-scale, and full-scale demonstrations at other sites (EPA, 1990; and EPA, 1991).

A disadvantage of this technology is that large volumes of washing fluid can be generated, requiring treatment and disposal.

Laboratory and/or pilot-scale testing would be required to confirm the feasibility and/or to determine the optimal on-site soil washing process design for the MTL site.

Recommendations — Because of the potential applicability of soil washing to on-site contaminants, on-site soil washing/extraction will be retained for further consideration.

3.3.5.3.2 Solvent Extraction

Description — This process is similar to soil washing except that a nonaqueous solvent is contacted with the contaminated media. The process can be a continuous countercurrent design or a batch system. Solvent contacts the contaminated soil and dissolves the contaminants from the soil. Treated soil and contaminated solvent emerge from the process. Treated soil can be disposed on-site or off-site while the solvent is recycled. Waste solvent concentrated with contaminants must be treated or disposed separately.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — The treated soil will contain residual solvent, so the key to solvent extraction is to use solvent that is not a hazardous substance. Solvent extraction is not effective on soils with a high water content. Bench-scale studies would be required to identify the best solvent and to establish operating parameters. Treated soil could be used as backfill, thus saving costs on disposal of contaminated soil as well as replacement backfill. Additional treatment and/or disposal would be required for spent solvent.

Recommendations — This process option will be retained for further consideration.

3.3.5.3.3 Solidification/Stabilization

Description — Solidification or stabilization, also referred to as immobilization, is a process that physically and/or chemically combines the soil materials with binding materials to decrease the mobility of the constituents. Application at the MTL site would involve excavation of the contaminated soils and conversion of these soils to a solid mass that would immobilize the leachable contaminants, followed by disposal on-site.

Various binding materials are available, including cement and pozzolanic materials (e.g., fly ash), which are widely used. Other binding agents include organic polymers or combinations of cement/pozzolan and polymers. In addition, the waste materials can be microencapsulated in thermoplastic materials such as asphalt.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — Solidification/stabilization has been successfully used to immobilize waste materials; however, certain binding materials are sensitive to wastes containing organics. Laboratory, bench-scale, and/or pilot-scale tests would be required to confirm the feasibility of the technology (i.e., show that the soil contaminants are

fully immobilized) and to determine the optimal binding material for the MTL site materials. On-site disposal may not be practical because of space imitations and the existence of a shallow water table.

Other Considerations — Some solidification/stabilization technologies experience a volume reduction; however, with other technologies and certain matrices, the immobilized waste volume may increase significantly. Therefore, on-site space limitations may limit implementation if on-site disposal is used. Material can be disposed off-site.

Recommendations — Solidification/stabilization will be retained for further consideration only to be used in conjunction with off-site disposal.

3.3.5.3.4 Macroencapsulation

Description — Macroencapsulation is a technique for containing waste materials by encapsulating large particles in an environmentally secure barrier. Materials such as lime or cement pozzolan, thermoplastics, or organic polymers are used to contain the waste in a nodule form that is surrounded by the encapsulating material.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — Macroencapsulation is attractive because the resulting nodules are isolated and exhibit low permeability and good bearing strength; however, product placement is very important and may require a secure landfill. Minor leaching is a possibility as a result of free liquid (i.e., wet soils/sediments or precipitation) exposed to the resultant product; however, if the macroencapsulation is successful, the leaching potential should be insignificant. In addition, laboratory and/or pilot-scale tests would be required to determine an optimum macroencapsulation material that would be compatible with the site waste materials and subject to minimal leaching.

Other Considerations — The risks associated with this technology include the possibility of leaching contaminated materials from the nodules that would pose a threat to the local environment, especially since the waste materials form a matrix at the node walls and are not uniformly dispersed in the encapsulating material.

Recommendations — Macroencapsulation will not be retained for further consideration because of environmental and technical reliability uncertainties.

3.3.5.4 Chemical Treatment Options for Excavated Soils

3.3.5.4.1 Chemical Oxidation

Description — In chemical oxidation, chemical transformations of the reactants occur and the contaminants are either destroyed or their toxicity is lowered by raising the oxidation state of one reactant while reducing that of another. The purpose of chemical

oxidation is to change hazardous substances into compounds that are safer in the environment.

The chemical oxidation process was developed for the treatment of soils and sludges containing PCBs, pesticides, PAHs, and VOCs. The oxidizing agent is contacted with the contaminated soils in an aqueous medium. This process differs from soil washing in that chemical transformation results, and unlike soil washing or solvent extraction, there is no liquid wastestream that will require separate removal and treatment.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — When the reaction is complete, both the contaminants and the oxidizing agent are transformed into nontoxic substances. The decontaminated soils are discharged from the process for disposal on-site or off-site. The entire process can take place in a single agitated semibatch reactor. Treatability testing would be required to determine optimal operating conditions. Treated soil could be used as backfill, thus saving costs on disposal of contaminated soil as well as replacement backfill.

Recommendations — This process option will be retained for further consideration.

3.3.5.4.2 Chemical Dechlorination

Description — Chemical dechlorination involves the removal of chlorine atoms from chlorinated organic compounds by chemical reaction with a reagent. The purpose of dechlorination is to change hazardous substances into compounds that are less harmful in the environment.

The chemical dechlorination process was developed for the treatment of soils and sludges containing PCBs, dioxins, and dibenzofurans. An alkali hydroxide, usually potassium or sodium hydroxide, is combined with polyethylene glycol to form an alkali polyethylene glycol (KPEG) or alkoxide. The alkoxide is the reagent used for dechlorination. Equal masses of soils and reagent are combined. This soil/reagent combination is heated to 100 to 180 °C, mixed thoroughly, and allowed to react for 1 to 12 hours. Mixing usually occurs throughout the reaction process. Dimethyl sulfoxide (DMSO), which has been shown to significantly reduce reaction time, is often used as a cosolvent for the reaction.

Areas of the Site — This process option is potentially applicable for PCB-contaminated site soils.

Technical Considerations — When the reaction is complete, excess reagent is decanted from the soils and recycled. The soils are then washed with water, and the decontaminated soils are discharged from the process for disposal on-site or off-site. The entire process can take place in a single agitated batch reactor. This process has also been effective at reducing the levels of metals present in soils by 30 to 50%.

Treatability testing would be required to determine optimal operating conditions and the effectiveness of recycling the reagent.

Recommendations — This process option will be retained for further consideration because of its applicability to PCB-contaminated soils.

3.3.5.5 Biological Treatment Options for Excavated Soils

3.3.5.5.1 Landfarming/Composting

Description — Landfarming methods are directed towards enhancing biochemical mechanisms to detoxify or decompose the contaminants in the soil. This is accomplished by oxygenating the soil and adding nutrients using agricultural machinery (i.e., tillers and plows) and an irrigation and drainage system. Native or specialized microorganisms can be used to biodegrade soil contaminants. The mechanism for composting is similar to landfarming; however, the soil materials are mixed in at a small percentage (≤10%) with a biodegradable and structurally firm material such as chopped hay or livestock feed.

For application at the MTL site, contaminated soils and sediments generated from dewatering operations would be excavated and placed on an asphalt pad for treatment. The pad would be sloped and bermed to provide drainage control.

Areas of the Site — This technology can potentially be applied to surface soils and subsurface soils.

Technical Considerations — Biological land treatment and composting techniques have been successfully used for the treatment of various organic compounds; however, the sensitivity of biological treatment warrants careful control of environmental conditions. The necessity of achieving background levels as cleanup goals may not be feasible by this technology.

High levels of some organics could be toxic to the microorganisms; therefore, laboratory and/or pilot-scale tests would be required to confirm the feasibility of this technology and to determine the optimum landfarming/composting technique for the problem areas of the site. It is anticipated that landfarming/composting would be most applicable to surface soils. It is possible that higher contaminant-level materials could be blended into lower contaminant-level soils to prevent injury to the microorganisms.

Other Considerations — Contaminants could be mobilized into the groundwater during treatment, thereby possibly threatening the local environment; therefore, strict operating conditions require that all work with contaminated soils be conducted on a drainage-controlled pad. This will prevent vertical migration of contaminants and the control of surface water and sediment runoff from the treatment area.

Some of the soil contaminants at MTL require aerobic biological treatment (i.e., with oxygen present), while others require anaerobic treatment (i.e., no oxygen present).

However, the contaminants are mixed such that some site soils would require both aerobic and anaerobic treatment to achieve remedial goals. Consequently, biological treatment at MTL would be cumbersome, would require extensive laboratory and pilot testing to segregate soils and select microorganisms, and would require years to complete. It is uncertain whether all organics can be successfully treated in this manner.

Recommendations — Landfarming/composting of soils will not be retained for further consideration because of the problems cited above, and because of the probable inability of this technology to achieve soil background levels.

3.3.5.5.2 Bioreactors

Description — This process involves the slurrying of contaminated soil with water in an agitated tank. The tank is equipped with an agitation system to allow for contact of the slurried soils with microorganisms, nutrients, and catalysts, which are added periodically. The temperature in the bioreactor can be controlled to allow for optimum reaction kinetics. The treatment periods range from 1 week to 4 months. The liquid effluent from the system generally requires treatment prior to discharge or recycling. The solid residue after treatment may be disposed on-site, depending upon residual contaminant levels, or transported off-site for disposal.

Areas of the Site — This process option is potentially applicable to excavated soils.

Technical Considerations — This process has been shown to be effective for the treatment of liquids, soils, and sludges containing PCBs and other organics; however, long time frames are required for treatment of PCBs. Extensive treatability studies would be required to identify suitable microorganisms, proper aerobic or anaerobic conditions, and to determine whether treatment goals can be achieved.

Recommendations — This process option is not retained for further consideration, as the overall volume of contaminated soils applicable for this option is not great enough to warrant the extensive treatability studies required for this option.

3.3.6 DISPOSAL TECHNOLOGIES

Disposal of contaminated soil and treatment by-products, such as sludge or spent carbon, in a landfill that meets applicable requirements would effectively contain the wastes and provide long-term security against direct exposure to the waste. Two potential options were considered: off-site disposal of materials in an existing, permitted landfill and disposal in an on-site landfill. Either approach may require treatment of the excavated wastes to meet land disposal regulations. Another soil disposal option for on-site treated soils is direct on-site disposal. Off-site reuse of contaminated soil is also a disposal option. Such reuse options include use in asphalt-batching facilities or use in a landfill as daily cover.

3.3.6.1 On-Site Disposal

3.3.6.1.1 On-Site Landfill

Description — On-site landfilling of contaminated materials at the MTL site would include the construction of a secure landfill or aboveground vault on-site, incorporating a double-liner system. The landfill or vault would require compliance with RCRA standards for both liner and cover systems. The contaminated materials would be partially or completely excavated and placed in the on-site landfill.

Areas of the Site — This technology can potentially be applied to surface soils, subsurface soils, and process wastes from treatment operations.

Technical Considerations — A below-grade landfill does not appear to be feasible because of the shallow water table at MTL; therefore, an aboveground landfill or vault would be required for on-site landfilling at MTL. This would need to be large enough to contain all of the excavated soils unless some soils were disposed off-site; however, because of the limitations of open space and future land-use considerations, any large on-site landfill facility would not be practical.

In addition to the RCRA design standards, post-closure care, maintenance, and leachate management would be required. Some contaminated materials may require solidification/stabilization prior to on-site disposal.

Other Considerations — The cost of this technology would be very high and would include design, construction, and operation of the landfill or vault. This technology does not require the transportation of waste material off-site and may provide secure containment on-site, but does not treat the contaminated materials.

Recommendations — On-site landfilling by an aboveground vault will not be retained for further consideration because this method of disposal has not been widely accepted or practiced, the large amount of material to be landfilled, and future land-use considerations at MTL. A below-grade landfill will not be retained for further consideration since it is technically infeasible because of the shallow water table at the site.

3.3.6.1.2 Direct On-Site Disposal of Treated Soil

Description — Direct on-site disposal of soil refers to the backfilling of excavations with the treated soil that was removed from the excavation.

Areas of the Site — This technology can be applied to surface soils and subsurface soils.

Technical Considerations — To use this option, excavated soil must be treated to all of the chemical-specific cleanup levels. If this level of treatment is not performed,

another disposal option must be selected. There are no other technical limitations to this option.

<u>Other Considerations</u> — This option allows for major cost savings for remediation, compared to off-site disposal, as minimal additional fill material will need to be purchased to backfill the soil excavations. In addition, there would be no required transportation of waste material off-site.

<u>Recommendations</u> — This technology will be retained for further consideration.

3.3.6.2 <u>Off-Site Disposal or Reuse</u>

3.3.6.2.1 Off-Site Disposal

<u>Description</u> — Off-site disposal involves excavation of the contaminated materials and transportation of the materials to an approved disposal site that meets applicable RCRA requirements and regulations.

<u>Areas of the Site</u> — This technology can potentially be applied to surface soils and subsurface soils.

<u>Technical Considerations</u> — This technology is feasible because all aspects of off-site disposal are based on standard engineering practices. RCRA requires a hazardous waste landfill to have a lined base and sides, a leachate and runoff collection system, and a final cover to reduce infiltration.

<u>Other Considerations</u> — Commercial disposal facilities must meet stringent analytical, state permitting, and compliance standards. Using off-site facilities requires meeting DOT requirements for hazardous waste transport. Commercial RCRA landfill capacity is limited; therefore, the type and quantities of waste must be approved by the facility prior to disposal. The off-site facilities may be reluctant to accept large quantities of waste.

There are no local environmental impacts associated with off-site disposal, providing that erosion and sediment control measures are followed during excavation activities, because the waste materials are removed from the site to a more secure location; however, this technology does not treat the contamination.

<u>Recommendations</u> — Off-site disposal at a RCRA facility will be retained for further consideration. This technology is feasible but may prove to be costly if all soils are disposed in this fashion.

3.3.6.2.2 Off-Site Reuse

<u>Description</u> — Off-site reuse involves excavation of the contaminated materials and transportation of the materials to an approved site that meets applicable requirements and regulations where the soil could be directly reused in a process. This includes

using the soils in an asphalt-batching process or using soils in a landfill as daily cover (as opposed to landfilling soil solely for disposal).

Areas of the Site — This technology can potentially be applied to all soils, depending on the contaminant content.

Technical Considerations — To use this option, the untreated soils must contain contaminant levels that are acceptable to the receiving facility and do not interfere with the reuse process or cause a risk through reuse. Certain soils at MTL would be unacceptable because of contaminant content. For example, untreated soil that contained any PCBs or pesticides could not be used as daily landfill cover, or any soil that was classified as hazardous. Asphalt batching plants will not accept hazardous soils or soils with PCB or PAH concentrations above the plant's specific limits.

Other Considerations — This option may allow for a substantial savings for remediation cost. However, reuse as described in the context of this FS is only applicable for nonhazardous soils. Some of the soils may be disposed by this fashion; however, other soil will require disposal by other means.

Recommendations — This technology will be retained for further consideration for nonhazardous soil only.

3.4 SELECTION OF REPRESENTATIVE PROCESS OPTIONS

This subsection presents the rationale for selecting a representative process option from each of the technology types that passed the screening described in Subsection 3.3. One representative process is selected, if possible, for each technology type to simplify the subsequent development and evaluation of alternatives, without limiting flexibility during the remedial design. The representative process provides a basis for developing performance specifications during the preliminary design; however, the specific process actually used to implement the remedial action at the site may not be selected until the remedial design phase, or until the results of bench- or pilot-scale testing are available. In some cases, more than one process option may be selected for a technology type. This may be done if two or more processes are sufficiently different in their performance or effect such that one would not adequately represent the other.

To aid in the preliminary selection of a representative process option, various evaluation factors were used to evaluate process options. These evaluation factors are presented below.

Effectiveness — The effectiveness of each process option was assessed by considering:

- The effectiveness of the process option in meeting potential goals.
- Potential impacts on human health and the environment during the construction and implementation phases.

- Demonstration of reliability of the process with respect to the contaminants and conditions at the site.

Implementability — Process options were evaluated with respect to the following implementability factors:

- The ability to meet substantive permit requirements and/or public acceptance.

- The availability of support services and equipment associated with the process option.

Cost — Process option cost factors were evaluated with respect to the relative capital and O&M costs of process options that provide similar results.

Process options for selected technologies for remediating contaminated soil have been further evaluated. The rationale for selecting representative process options is discussed in the following subsections. The results of the process option evaluation for contaminated soil are summarized in Figure 3-5. Technologies for which only one process option remains are incorporated into remedial alternatives without further evaluation. The no action option has been incorporated into remedial alternatives without further evaluation.

3.4.1 Institutional Actions

For access and use restrictions, deed restrictions and physical barriers were retained for further analysis. While neither reduce the amount of contamination present, they do reduce the risk by limiting contact with the contaminant. Barriers would prevent entrance onto contaminated areas of the site. Deed restrictions would prevent certain uses of the property that may cause exposure to contaminants. The effectiveness of both depends on their continued future implementation. Both options have been retained for further evaluation.

3.4.2 Containment

Asphalt cap and runon/runoff controls have been retained as process options. The two options would be implemented together during the construction of the cap. The cap would effectively eliminate exposure to soil contaminants. Runon/runoff controls could also be used in conjunction with soil removal during excavation. Both process options are retained for further evaluation.

3.4.3 Treatment Options

The thermal treatment options retained for further evaluation were incineration and thermal desorption. Regardless of the thermal treatment technology selected, considerable handling may be required to prepare the soil to the required feed size and quality for treatment.

Incineration, while expensive, is a more developed and demonstrated technology, and is capable of accepting a variety of waste material. Removal efficiencies of >99.9999% can be achieved, virtually guaranteeing complete destruction of organic contaminants present at the site. However, after incineration, the treated material may be considered a solid waste; therefore, it may not be used to backfill the excavation without a containment system.

Low-temperature thermal desorption also has proven effective in treating organic-contaminated soil. It is expected that thermal desorption could achieve the desired contaminant destruction efficiencies; however, to ensure that adequate removals are obtained, it is recommended that bench-scale testing be conducted on the contaminated soil. This technology has significant cost and regulatory advantages over incineration technologies because it would be less energy-intensive, would not require as extensive an emissions control system, and would not concentrate volatile metals. In addition, this technology would not produce a solid waste (by definition); therefore, treated soil could be placed back in the excavation without further action. Recovered contaminants would require further treatment or disposal. Both incineration and thermal desorption are retained for further analysis.

The physical treatment options retained for further evaluation were solvent extraction and solidification/stabilization. Solvent extraction would be effective in separating the contaminants from the soil. Bench-scale testing would be required to determine the best type of nontoxic solvent. Separated contaminants would require further treatment or disposal. Solidification/stabilization would be used if needed in conjunction with off-site disposal of untreated soil or treatment residuals generated from incineration, thermal desorption, or solvent extraction. Both process options are retained for further evaluation.

The chemical treatment options retained for further evaluation were oxidation and dechlorination. Both options require excavated soil to be processed in agitated reactors with the addition of various agents to destroy or dehalogenate VOCs. Chemical oxidation offers two major advantages over dechlorination: effectiveness and cost. Oxidation offers total destruction of VOCs, SVOCs, pesticides, and PCBs. The process was originally designed to destroy chlorinated VOCs. Dechlorination was originally designed to treat dioxins, PCBs, and dibenzofurans. Dechlorination may result in the production of other toxic species, and the dechlorination reaction solvents themselves are toxic. Oxidation, by initial estimates, would be a less costly option than dechlorination because oxidation requires less capital equipment, and oxidation has a higher process rate and shorter reaction time. For these reasons, chemical oxidation has been selected as the chemical treatment process option.

3.4.4 Disposal Options

The off-site disposal options retained for further evaluation were landfill and off-site reuse, such as landfill daily cover or asphalt-batching. For any off-site disposal, the characterization of the soil would determine which option was used. Off-site reuse, which is preferred by Massachusetts, requires a nonhazardous soil that would meet the

requirements of the reuse facility. Any soil that did not meet the requirements could not be reused and would require disposal in an approved landfill. Both options are retained for further analysis. On-site disposal would only be used for soils that were treated to the cleanup goals.

SECTION 4

DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES

In Section 3, various remedial technology process options were screened for their applicability to the outdoor areas of the MTL site. In this section, the technology process options retained for further consideration are combined into remedial alternatives for each medium of concern at the site. These remedial alternatives are then screened on the basis of their effectiveness, implementability, and cost. The alternatives that survive this screening are subjected to detailed analysis in Section 5.

Subsection 4.1 presents the rationale for developing remedial alternatives. These alternatives were assembled from the process options identified and screened in Section 3 to meet the remedial action objectives. Subsection 4.2 presents a screening of the alternatives. In this subsection, these potential alternatives are screened on the basis of their effectiveness, implementability, and cost in relation to the site, waste, and technology characteristics. The effectiveness evaluation focused on the reliability of the technology, including its stage of development, performance, and reliability in meeting the action levels for this site. The implementability discussion primarily involved institutional and technical concerns. Finally, costs of implementing a particular option were considered on a relative basis. Capital and O&M costs were generally qualified as low, moderate, or high, relative to process options of the same technology type. Based upon these considerations, a recommendation was made to retain or eliminate the alternative from further consideration.

4.1 DEVELOPMENT OF ALTERNATIVES

Remedial alternatives were developed to represent various levels of protection for human health and the environment. The alternatives consist of:

- Alternatives that eliminate, to the extent feasible, the need for long-term management at the site.
- Alternatives that use treatment as a primary component to reduce the toxicity, mobility, or volume (TMV) of contaminated materials.
- Alternatives that involve containment to prevent potential exposure and/or to reduce the mobility of contaminants.
- Alternatives that involve only institutional actions to prevent potential exposure to contaminants.
- A no-action alternative.

Specific remedial objectives were discussed in Section 2. The rationale for formulating the remedial alternatives is presented in Subsection 4.1.1. Alternatives are screened in Subsection 4.2.

4.1.1 SOIL REMEDIATION ALTERNATIVES

Specific response actions incorporated into the development of alternatives to meet remedial objectives for contaminated soil are as follows:

- No action.
- Institutional actions.
- Containment.
- Removal/treatment/disposal.

4.1.1.1 No Action

The no-action alternative has been evaluated to satisfy the requirements of 40 CFR 300.68(f), which requires consideration of this alternative as a baseline against which other alternatives may be compared. Under this alternative, contaminated soil would remain in the surface and subsurface. Only natural processes would degrade organic contaminants.

4.1.1.2 Institutional Actions

One alternative was developed to address institutional actions performed at the site. Such actions would not remediate the contaminants but would reduce risk by limiting exposure to the contaminants. Such actions include placing signs and fencing around contaminated areas, upgrading site security to prevent unauthorized access to fenced areas, and placing deed restrictions on property transactions to prevent agricultural use of contaminated soil.

4.1.1.3 Containment

One alternative was developed to contain contaminants on-site such that site risk was minimized by reducing exposure to contaminants. This would be accomplished by placing an asphalt cap over the contaminated soil areas. Long-term maintenance of the cap would be required to ensure it remained a viable physical barrier preventing exposure to contaminants.

4.1.1.4 Removal/Treatment/Disposal

Three alternatives were developed that involved the removal of contaminated soil by excavation followed by on-site or off-site treatment or disposal. One alternative uses thermal treatment process options for soil treatment after excavation. This alternative was separated into three options where each option uses a different thermal treatment. The three options are on-site incineration, off-site incineration, and on-site thermal desorption. A second alternative uses physical or chemical process options for soil

treatment after excavation. This alternative was separated into two options where each option uses a different process option. One option uses chemical oxidation for treatment; the other option uses solvent extraction. The third alternative uses off-site disposal as the method to remove soil contaminants after excavation. Depending on the characteristics of the excavated soil, off-site disposal could include recycling as daily landfill cover or at an asphalt-batching plant as well as disposal in an approved landfill.

All three alternatives include backfilling of the excavations after contaminants have been removed. For on-site treatment alternatives, the treated soil would be backfilled on-site if soil cleanup goals were achieved.

4.1.2 MTL REMEDIAL ACTION ALTERNATIVES

Alternatives that include remedial technologies that provide various levels of protection have been developed for the MTL site. These include six alternatives for soil. Soil alternatives have been given the designation "S" prior to their numbers.

Soil alternatives, summarized in Table 4-1, are as follows:

- Alternative S1 is no action.
- Alternative S2 is institutional actions which includes access and deed restrictions.
- Alternative S3 is the containment alternative in which an asphalt cap is placed over the contaminated soil areas.
- Alternative S4 involves excavation of contaminated soil followed by thermal treatment and backfilling. This alternative contains three options for thermal treatment:
  - Option A - On-site incineration
  - Option B - Off-site incineration
  - Option C - On-site thermal desorption
- Alternative S5 involves excavation of contaminated soil followed by on-site physical/chemical treatment and backfilling. This alternative contains two options for treatment:
  - Option A - Chemical oxidation
  - Option B - Solvent extraction
- Alternative S6 involves excavation of contaminated soil followed by off-site disposal or reuse and backfilling.

Table 4-1

Alternatives for Remediation of Soil
U.S. Army Materials Technology Laboratory

Alternative S1 - No Action • No remedial actions implemented at the site.
Alternative S2 - Institutional Actions • Access restrictions to prevent entry into contaminated areas. • Deed restrictions to restrict site development. • Five-year site reviews to assess conditions.
Alternative S3 - Capping of Soils • Institutional controls. • Five-year site reviews to assess conditions. • Construction of asphalt cap over contaminated soils. • Use of runon/runoff controls during cap placement. • Continued monitoring of cap and repair of cap as necessary.
Alternative S4 - Soil Excavation and Thermal Treatment • Excavation of soil contaminated at levels greater than action levels. • Transportation of soil to: - Option A - On-site incinerator - Option B - Off-site incinerator - Option C - On-site low-temperature thermal desorber • Backfilling of site with uncontaminated soil (Option B) or treated soil (Options A and C).
Alternative S5 - Soil Excavation and On-Site Physical/Chemical Treatment • Excavation of soil contaminated at levels greater than action levels. • On-site treatment of contaminated soil by: - Option A - Chemical oxidation - Option B - Solvent extraction • Treatment or disposal of treatment residues. • Backfilling of site with treated soil.
Alternative S6 - Soil Excavation and Off-Site Disposal or Reuse • Excavation of soil contaminated at levels greater than action levels. • Transportation of soil for off-site recycle or to hazardous or nonhazardous landfill. • Backfilling of site with uncontaminated soil.

4.2 SCREENING OF SOIL REMEDIATION ALTERNATIVES

4.2.1 ALTERNATIVE S1 - NO ACTION

Under this alternative, no remedial action would be performed at the site. There would be unlimited access to the site for potential exposure to contaminants.

Effectiveness - This alternative would not be effective in achieving remedial goals or in reducing risk by limiting future exposure of humans to site contaminants. It would not reduce the toxicity, mobility, or volume of contaminated materials present at the site. Some degradation of the organics would occur, but it would be very slow (years).

Implementability — This alternative requires no implementation.

Cost — There would be no costs for implementing this alternative.

Recommendation — This alternative will be retained for detailed analysis to serve as a baseline against which to compare other alternatives as required by the NCP.

4.2.2 ALTERNATIVE S2 — INSTITUTIONAL ACTIONS

Under this alternative, no actions would be implemented to remediate contaminants; however, measures would be taken to reduce potential risks to human health and the environment, including placing a fence around the contaminated areas, upgrading site security, and implementing deed restrictions to limit future reuse (either residential or commercial) . A periodic site review (required under CERCLA) would occur every 5 years to determine any changes in conditions and if any additional actions would be warranted for the site. Current levels of contamination would be left in place, and no changes in contaminant levels would be expected except those resulting from natural processes (i.e., biodegradation or weathering).

Effectiveness — This alternative would be effective in limiting future exposure of humans to site contaminants by restricting future access and land use; however, it would not reduce the toxicity, mobility, or volume of contaminated materials present at the site. Some degradation of the organics would occur, but it would be very slow (years).

Implementability — This alternative can be readily implemented with nominal legal actions, fencing, and increased security. Cooperation must be achieved with local officials to ensure that proper deed restrictions are placed and enforced. This alternative may impact future site reuse.

Cost — Costs for implementing this alternative are expected to be low.

Recommendation — This alternative will be retained for detailed analysis.

4.2.3 ALTERNATIVE S3 – CAPPING OF SOILS

Under this alternative, an asphalt cap would be constructed over the areas where contaminated soils are present at greater than action levels. The use of the asphalt cap is intended to serve as a physical barrier to prevent direct human contact with the contaminated soils. This alternative would also include deed restrictions for the capped areas to ensure no development occurred in these areas as well as the five-year CERCLA site reviews.

Effectiveness – Capping is a well-known technology that can be expected to effectively minimize future contact with contaminated soil. Caps are subject to long-term degradation caused by erosion and weathering, which reduce the effectiveness of the caps and allow for potential exposure to the contaminated soils. Asphalt caps are more susceptible to failure than other types of caps because of cracking from freeze/thaw cycles and, therefore, can require a significant amount of maintenance.

As with the no action alternative, current levels of contamination in the soil would be left in place, and no changes in contaminant levels would be expected except those resulting from natural processes (i.e., biodegradation or weathering).

Implementability – Caps are constructed using conventional techniques and, therefore, would be easily installed. A properly designed and constructed cap would have a useful life of more than 20 years; however, much of the soil contamination would remain at the end of this period. Cooperation must be achieved with local officials to ensure that proper deed restrictions are placed and enforced. The presence of a cap and deed restrictions may affect potential future site reuse.

Cost – Capital costs for capping involve design and construction of the cap. Capital costs for implementation of this alternative are expected to be low to moderate. O&M costs can be moderate because of the maintenance and repair that will be required throughout the life of the cap. The cap may require replacement after its useful life is over.

Recommendation – This alternative will be retained for detailed analysis.

4.2.4 ALTERNATIVE S4 – SOIL EXCAVATION AND THERMAL TREATMENT

Under this alternative, soil contaminated at levels greater than action levels would be excavated and treated thermally. This can be accomplished by three methods: on-site incineration, off-site incineration, or low-temperature thermal desorption. Each method is evaluated separately in the following subsections.

4.2.4.1 Option A – On-Site Incineration

Effectiveness – This option would be effective in reducing risk by excavating and incinerating contaminated soils on-site. Incineration would be effective for destroying organics, including PCBs. Any heavy metals would remain in the processes and might

require further treatment. Rotary kiln incinerators have achieved the applicable standard of 99.9999% destruction and removal efficiency for PCB-contaminated materials. Treated soil can be used as clean backfill and returned to the excavation unless the soil is hazardous as a result of metals concentrations, which is not anticipated at MTL.

Implementability — This alternative would be implementable but there could be a substantial delay in actual treatment because of permitting and trial burn requirements (an often lengthy process). As a Superfund site, the administrative requirements to obtain an actual permit may not be necessary, but conditions of any such permit must be adhered to. Excavation would be accomplished using conventional techniques. Trial burns would be required to demonstrate the effectiveness to destroy all the soil contaminants to required goals.

Cost — The cost of this alternative is expected to be moderate to high. Costs are minimized with this option as a result of the use of a mobile incinerator. This option is more economical than off-site incineration for larger quantities of soil because of large startup costs from test burns and mobilization; however, this option does not have the high transportation costs that would be incurred for off-site incineration.

Recommendation — This option will be retained for detailed analysis.

4.2.4.2 Option B — Off-Site Incineration

Effectiveness — This option would be effective in reducing risk by excavating and transporting contaminated soils off-site. Incineration would be effective for destroying organics, including PCBs. Any heavy metals would remain in the processes and might require further treatment at the incineration site. Transportation has risks associated with accidents that would release the contaminated materials; however, since these materials consist entirely of soils that present only chronic health risks, this is not a major concern.

Rotary kiln incinerators have achieved the applicable standard of 99.9999% destruction and removal efficiency for site-related contaminants. There are several permitted facilities in the United States that have incinerators capable of incinerating contaminated soil. The concentration of PCBs in the soil is not high enough to require a TSCA facility to incinerate the soils.

Implementability — This alternative would be readily implementable since there is a moderate volume of material requiring excavation and transportation to the incinerator. Excavation would be accomplished using conventional techniques. Transportation of the soil to the off-site location would be necessary, but finding a suitable off-site incineration facility should not be difficult. Depending on the facility backlog, there may be some difficulty in scheduling treatment.

Cost — The cost of this alternative is expected to be high. There should be low on-site costs associated with this option because of removal of the contaminants from the site.

Clean backfill would have to be purchased to fill the excavated areas. This cost would be moderate. This option is more economical than on-site incineration for smaller quantities of soil because this option does not have the high startup and mobilization costs that are incurred for on-site incineration. Transportation costs for this option, however, can be high.

Recommendation — This option will be retained for detailed analysis.

4.2.4.3 Option C — Low-Temperature Thermal Desorption

Effectiveness — This option would be effective in reducing risk by excavating and treating contaminated soils on-site through thermal desorption. The desorption process does not destroy the organic contaminants directly but decontaminates the soil when the organics are desorbed from it. The contaminants remain in the off-gases that are collected and treated by processes such as carbon adsorption or thermal destruction.

Implementability — This alternative would be readily implementable since there is a moderate volume of material requiring excavation and thermal desorption but there could be a substantial delay in actual treatment because of permitting and trial testing requirements (an often lengthy process). As a Superfund site, the administrative requirements to obtain an actual permit may not be necessary, but conditions of any such permit must be adhered to. Excavation would be accomplished using conventional techniques. Trial test runs would be required to determine the optimal operating conditions (temperature and residence time). The on-site unit may have to be operated at different conditions to remove the variety of contaminants.

Cost — The cost of this alternative is expected to be moderate. This option is expected to be more economical than on-site or off-site incineration. Low-temperature thermal desorption would not have the high transportation costs associated with off-site incineration. Also, thermal desorption costs are not as high as for incineration off-gas treatment, since the heating systems are kept independent of the wastes, unlike incineration.

Recommendation — This option will be retained for detailed analysis.

4.2.5 ALTERNATIVE S5 — SOIL EXCAVATION AND ON-SITE PHYSICAL/CHEMICAL TREATMENT

Under this alternative, soils contaminated above action levels would be excavated and treated on-site. Treatment process options include chemical oxidation (in which the soils are treated with oxidizing agents to destroy the organics) and solvent extraction (in which the soils would be contacted with water-immiscible solutions that would extract contaminants). The treated soils would be tested to verify treatment effectiveness. The soils would then be used as backfill if treatment goals are met or disposed off-site if the goals cannot be achieved. Any treatment residuals from the soil treatment processes would be treated further or disposed off-site. The individual treatment options are evaluated separately in the following subsections.

4.2.5.1 Option A — Chemical Oxidation

Effectiveness — This process would potentially be effective in treating organic contamination, including PCBs. The reagent requirements of the process would need to be evaluated by conducting treatability studies on site soils.

According to vendors, a single proprietary mixture of nontoxic oxidizing agents would be effective for all the organic contaminants present in MTL soils. The treatment residuals in the soil would be sufficiently low to allow on-site backfilling of the soils. There would be no reagent residual or treatment wastestream that would require additional handling.

There has been much documentation available in recent years for this process and its applications. Documented applications include treatment for petroleum hydrocarbons, pesticides, PAHs, and PCBs.

Implementability — This option would be readily implementable. The process is accomplished with a mobile unit that uses a soil mixer as the reaction vessel. Implementation of this option would involve site preparation, excavation of contaminated soils, and on-site placement or off-site disposal of treated soils.

This alternative would require a treatability study to determine the usage of reagent and removal efficiency of the process. The system cannot be used if PCB levels exceed 50 ppm, because this would require TSCA permitting. Such levels are not present at MTL.

Cost — Initial setup costs for this option would be very low, because this option uses a mobile unit. Costs would include treatability studies, excavation of the soils, operation of the process, sampling of the treated soils, and placement of the treated soils. Case histories have shown that this technology can be more economical than other treatment, incineration, or disposal options. The cost factor determining economic viability is the cost of oxidizing agent, which is determined by reagent dosage requirements. Reagent dosage estimates suggest treatment costs will be low.

Recommendation — This option will be retained for detailed analysis.

4.2.5.2 Option B — Solvent Extraction

Effectiveness — The solvent extraction process would be potentially effective on the organic contamination present at the site. The basic principles for solvent extraction are similar to soil washing except that soil washing involves aqueous solutions and solvent extraction solutions are not water soluble. Recent innovations in solvent extraction have led to the development of several solvent extraction processes using solvents that vendors claim are environmentally safe and more efficient than soil washing solutions. The effectiveness of any particular solvent would require bench-scale or pilot-scale testing.

Residual amounts of solvent will be present in the treated soil; however, if the solvent is not harmful to human health and the environment, no treatment for the solvent is required. The spent solvent is flashed, and vaporized solvent is condensed and reused. This results in a small-volume waste solvent/contaminant solution that requires disposal; the majority of the solvent is reused.

Implementability — Implementation of this alternative would require site preparation, design and construction of the solvent extraction system, excavation of soils, on-site placement of treated soils, and off-site disposal of waste solvent. Solvent extraction systems, each with a different proprietary or patented solvent, are currently being marketed by a number of vendors. All aspects of this alternative are readily implementable.

This alternative would require a treatability testing program to determine the type and usage of reagent and removal efficiency of the process.

Cost — Initial setup costs for this option include the treatability studies and the design and construction of the system. Other costs include labor, system operation, excavation and treatment of soils, replacement of treated soils, and disposal of unrecyclable solvent. Short-term costs are expected to be moderate.

Recommendation — This option will be retained for detailed analysis.

4.2.6 ALTERNATIVE S6 – SOIL EXCAVATION AND OFF-SITE DISPOSAL OR REUSE

Under this alternative, soils contaminated at levels greater than action levels would be excavated and transported off-site for disposal. The soil would be used for off-site recycling (such as daily landfill cover or asphalt-batching) or taken to either a nonhazardous or hazardous waste landfill, depending on the characteristics of the soil. Prior to transport off-site, the soil would be sampled and analyzed for hazardous criteria.

Effectiveness — This alternative would be effective in reducing risk by excavating and transporting the soil to a secure off-site landfill or off-site recycling facility. Disposal of excavated materials at an off-site landfill or recycling facility is a straightforward approach to management of the contaminated soil. The risks associated with accidents during transportation that could release the contaminated materials are minimal. This option would not destroy the contaminants, but would only transport them to another location; asphalt-batching recycling would bind the contaminants into the asphalt product. Landfilling of site contaminants would be subject to the land disposal, restrictions for any soils that were hazardous wastes. Any applicable universal treatment standards under Land Disposal Restriction Regulations would have to be met prior to landfilling. Based on current information, the most likely hazardous waste soil classification to be encountered is for the toxicity characteristic caused by chlordane, so the universal treatment standard for chlordane would need to be achieved (if not already achieved based on initial sampling analysis results).

Implementability — This alternative would be readily implemented. Excavation would be accomplished using conventional techniques. If any treatment is required to meet Land Disposal Restrictions, this treatment could be accomplished prior to shipment or at the off-site location. Transportation of the soil to the off-site location would require compliance with DOT transportation and shipping requirements.

The primary factors to be addressed in the implementation of this technology include sufficient characterization of the wastes to obtain acceptance at a recycling facility or landfill and finding a suitable landfill.

Cost — The capital cost of this alternative is expected to be high for disposal at a landfill. Significantly lower costs will result if the soil is recycled. These costs will include the costs for excavation, transportation, and disposal of the soil. These costs could be moderate to very high, depending on whether the soil is disposed as hazardous waste or nonhazardous waste. After the soil is disposed of and the excavation is backfilled, costs should be minimal because contaminants will be removed from the site; however, some liability associated with the landfill remains.

Recommendation — This alternative will be retained for detailed analysis.

4.3 SUMMARY OF REMEDIAL ALTERNATIVE SCREENING PROCESS

A summary of the remedial alternative screening process for soil at MTL is provided in Table 4-2. For each remedial alternative or alternative option, a decision of acceptance or rejection is given along with the rationale for that decision. All alternatives screened in this section have been retained for detailed analysis. They are listed in Table 4-3 and will be evaluated in the detailed analysis of remedial alternatives performed in Section 5.

Table 4-2

Screening of Soil Alternatives
U.S. Army Materials Technology Laboratory

Remedial Alternative	Effectiveness	Implementability	Cost	Recommendation
Alternative S1 - No action	Would not be effective in achieving remedial goals or reducing risk.	No implementation required.	None.	Retained for detailed analysis as required by the NCP.
Alternative S2 - Institutional actions	Would be effective by limiting access to site and preventing undesired use of contaminated soils. No contaminant reduction would be accomplished.	Legal requirements must be met for deed restrictions. Security measures and fencing would be easily implementable.	Low capital and O&M costs.	Retained for detailed analysis.
Alternative S3 - Capping of soils	Capping, along with deed restrictions, would be effective in reducing risks of contact with contaminated soil.	This alternative would be readily implementable because of the limited area requiring a cap and the generally flat topography of the site. Land-use restrictions would limit future uses of land.	Moderate capital costs; moderate O&M costs.	Retained for detailed analysis.
Alternative S4 - Option A - Soil excavation and treatment using on-site incineration	Would be effective in reducing risk by excavating and incinerating soils on-site. Incineration would destroy organics. Treated soil could be backfilled on-site.	This alternative would be implementable but could be delayed because of permitting requirements. Trial burns would be required to determine optimal conditions.	High capital costs; no O&M costs.	Retained for detailed analysis.
Alternative S4 - Option B - Soil excavation and treatment using off-site incineration	Would be effective in reducing risk by excavating and incinerating soils off-site. Incineration would destroy organics. Transportation has risks associated with accidents.	This alternative would be readily implementable because of the volume of material to be incinerated. Off-site transportation of the soil would be required.	High capital costs; no O&M costs.	Retained for detailed analysis.

Table 4-2

Screening of Soil Alternatives
U.S. Army Materials Technology Laboratory
(Continued)

Remedial Alternative	Effectiveness	Implementability	Cost	Recommendation
Alternative S4 - Option C - Soil excavation and treatment using low-temperature thermal desorption	Would be effective in reducing risk by excavating and thermally treating soil on-site. Thermal desorption would remove organics from the soil. Contaminants collected in off-gases would be treated by thermal destruction or carbon adsorption.	This alternative would be implementable but could be delayed because of permitting requirements. Trial tests would be required to determine optimal operating conditions.	Moderate to high capital costs; no O&M costs.	Retained for detailed analysis.
Alternative S5 - Option A - Soil excavation and on-site chemical oxidation	Would be effective on organic contaminants in the soil. No side wastes are produced by the reaction. Organics are destroyed by the treatment system.	This option involves a mobile unit. Treatability studies would be required to determine reagent dosage and removal efficiency.	Moderate capital costs; no O&M costs.	Retained for detailed analysis.
Alternative S5 - Option B - Soil excavation and on-site solvent extraction	Would be effective on organic contaminants in the soil. The solvent would be nontoxic so traces of solvent remaining in treated soil would not require further treatment. Solvent can be recycled, minimizing waste requiring disposal.	This option would require construction of an on-site treatment system. Treatability studies would be necessary to determine appropriate solvent and treatment efficiency.	Moderate capital costs; no O&M costs.	Retained for detailed analysis.

Table 4-2

Screening of Soil Alternatives
U.S. Army Materials Technology Laboratory
(Continued)

Remedial Alternative	Effectiveness	Implementability	Cost	Recommendation
Alternative S6 - Soil excavation and off-site disposal or reuse	Excavation and off-site disposal or recycling would be effective in reducing risks from contaminated soil; however, the generator maintains some degree of liability if landfill disposal is used. Transportation has risks associated with accidents.	This alternative would be implementable because of the moderate volumes requiring excavation and off-site transport. Testing would be required to determine compliance with recycling facility and/or land disposal requirements.	Moderate to high capital costs; no O&M costs.	Retained for detailed analysis.

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Table 4-3

Remedial Alternatives Retained for Detailed Analysis U.S. Army Materials Technology Laboratory

Remedial Alternatives for Soils

- Alternative S1 - No Action
- Alternative S2 - Institutional Actions
- Alternative S3 - Capping of Soils
- Alternative S4 - Soil Excavation and Thermal Treatment
    - Option A - On-Site Incinerator
    - Option B - Off-Site Incinerator
    - Option C - On-Site Low Temperature Thermal Desorption
- Alternative S5 - Soil Excavation and On-Site Physical/Chemical Treatment
    - Option A - Chemical Oxidation
    - Option B - Solvent Extraction
- Alternative S6 - Soil Excavation and Off-Site Disposal or Reuse

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SECTION 5

DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

5.1 INTRODUCTION

This section develops and analyzes remedial alternatives that were retained during the remedial technology and alternative screening processes described in Sections 3 and 4. The remedial alternatives were developed to address the remedial action objectives established for the MTL site as presented in Section 2. Six remedial alternatives were developed to provide an appropriate range of options and sufficient information to allow comparison among alternatives.

The remedial alternatives listed below are specific to soil. Alternatives are designated by the prefix "S":

- Alternative S1 - No action.
- Alternative S2 - Institutional actions.
- Alternative S3 - Capping of soils.
- Alternative S4 - Soil excavation and thermal treatment.
- Alternative S5 - Soil excavation and on-site physical/chemical treatment.
- Alternative S6 - Soil excavation and off-site disposal or reuse.

All of the remedial alternatives for soils, with the exception of no action, institutional actions, and capping involve the excavation of contaminated soils followed by either on-site treatment or off-site treatment/disposal.

5.2 ANALYSIS CRITERIA

The following criteria are used to evaluate each of the alternatives and represent the basis upon which the analysis is structured:

- Overall protection of human health and the environment.

- Compliance with ARARs.

- Long-term effectiveness and permanence.

- Reduction of toxicity, mobility, and volume of contaminants through treatment.

- Short-term effectiveness.

- Implementability.

- Cost.

- State acceptance.
- Community acceptance.

The criteria are categorized into three groups:

Threshold Criteria - These criteria are required to be met for an alternative in order to be eligible for selection. Threshold criteria are: (1) overall protection of human health and the environment; and (2) compliance with ARARs.

Primary Balancing Criteria - These criteria are: (1) long-term effectiveness and permanence; (2) reduction of toxicity, mobility, and volume of contaminants through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost.

Modifying Criteria - These criteria are: (1) state acceptance; and (2) community acceptance. These criteria shall be considered in remedy selection.

Each of the nine criteria for detailed analysis are explained further in the following subsections.

5.2.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This evaluation criterion assesses whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under the other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative will focus on whether it achieves adequate protection and will describe how site risks are eliminated, reduced, or controlled through treatment, engineering, or institutional controls.

5.2.2 COMPLIANCE WITH ARARs

This criterion is used to determine whether each alternative complies with ARARs under federal environmental laws and state environmental or facility siting laws, or provides grounds for a waiver. The chemical-, location-, and action-specific requirements are discussed along with any other appropriate criteria, advisories, and guidances as they apply to each alternative.

5.2.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

This evaluation criterion involves consideration of the risks that remain after the site has been remediated to acceptable levels as indicated in the remedial response objective. Items of concern are the presence of any receptors near the site, the magnitude of the

remaining risks, the adequacy of controls that are used to manage treatment residuals, and the reliability of these controls.

5.2.4 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

Consideration of this evaluation criterion is a result of recent statutory preference for selecting remedial actions that permanently and significantly reduce the toxicity, mobility, or volume of the contaminants and associated media. The following factors are considered in this evaluation:

- The treatment process and the materials to be treated.
- The amount of hazardous materials that will be treated.
- The degree of reduction in toxicity, mobility, or volume expected.
- The degree to which treatment will be irreversible.
- The type and quantity of materials that remain after remediation.
- The degree to which the treatment reduces the hazards at the site.

5.2.5 SHORT-TERM EFFECTIVENESS

This evaluation criterion involves the investigation of the effects of the alternative during construction and implementation. Factors considered include the protection of the community and the workers during implementation of remedial measures, potential environmental impacts, and the time required to achieve the remedial response objective. Prior to the actual field implementation of any alternative, the Army estimates that a period of 18 to 24 months will be required to complete documents required by the FFA and to complete the procurement process. This 18 to 24 month period is not included in the discussion of time required to achieve the remedial objective for the individual alternatives, and is considered to be additional time needed to achieve the objective.

5.2.6 IMPLEMENTABILITY

This criterion establishes the technical and administrative feasibility of implementing an alternative. Technical aspects evaluated for each alternative include construction and operation activities, ease of undertaking additional remedial action, and monitoring after completion of activities. Administrative concerns include establishing contact with appropriate agencies to implement remedial actions (i.e., obtaining permits or approval for off-site activities). Availability of materials and equipment needed is another factor that must be considered when evaluating the implementability of an alternative.

5.2.7 COST

This evaluation criterion provides information as to the capital and O&M costs of the alternative. All costs are estimated in 1995 dollars. Capital costs include design, construction, site preparation, equipment, and procurement fees. O&M costs include labor, equipment repair, expendable treatment costs (chemicals), and monitoring.

Additional cost considerations include environmental restoration costs such as wetlands, surface waters, and wildlife. Environmental restoration considerations are not applicable for soil remediation at MTL. A present worth cost analysis is performed for each alternative so the costs of each alternative can be equally compared. For the analysis, a maximum 30-year lifetime for alternatives was used. The net present worth is based upon a real interest rate (prime rate minus inflation rate) of 3% as recommended in OSWER Directive No. 9355.3-20 dated June 25, 1993.

Estimates for capital and O&M costs were based from a number of sources. For conventional technologies and work tasks, historical costing information was used as a baseline. For innovative technologies, current literature and the EPA database entitled Vendor Information System for Innovative Treatment Technologies (VISITT) were used as a baseline. The information baselines for both conventional and innovative technologies were supplemented with actual current cost estimate quotes from vendors and suppliers. When possible, local Massachusetts vendors were contacted for pricing information.

Because of the different site reuse scenarios at MTL, as discussed in Subsection 3.1, each soil alternative (except Alternatives S1 and S2) has separate cost tables for each of the three reuse scenarios developed for the site. The site reuse scenarios are as follows:

Scenario 1 — Commercial reuse for Zones 1, 2, and 3; public access for Zone 4 and River Park.

Scenario 2 — Residential reuse for Zones 1, 2, and 3; public access for Zone 4 and River Park

Scenario 3 — Commercial reuse for Zones 1 and 2; residential reuse for Zone 3; and public access for Zone 4 and River Park.

5.2.8 STATE ACCEPTANCE

This assessment evaluates the technical and administrative issues and concerns that the state may have regarding each of the alternatives. This criterion will be addressed in the ROD once the public comment period is completed. However, the MADEP has been involved in activities at the site throughout the RI/FS process at MTL and has reviewed this FS.

5.2.9 COMMUNITY ACCEPTANCE

This assessment evaluates the issues and concerns that the public may have regarding each of the alternatives. This criterion will be addressed in the ROD once the public comment period is completed.

5.3 EVALUATION OF ALTERNATIVE S1 – NO ACTION

5.3.1 DESCRIPTION

The no action alternative for MTL provides a basis for comparing existing site conditions with those resulting from the implementation of other remedial alternatives. Under this alternative, no remedial actions or mitigation actions are performed for site soils. Removal of contaminants from the source areas would be dependent upon the dynamics of natural processes such as biodegradation, dispersion, and adsorption/desorption. The only activity to be performed for this alternative would be a SARA review, which would occur every five years.

5.3.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The no action alternative does not eliminate, reduce, or control the risks at the site from the soil contaminants, and therefore would not adequately protect human health and the environment. Soil cleanup goals may be achieved over a long time if the contaminant concentrations are reduced as a result of natural attenuation processes. There would be no additional risks to workers or the community by implementing this alternative. The magnitude of residual risk would only be reduced by the reduction of contaminant concentrations as a result of natural attenuation processes over the long term.

5.3.3 COMPLIANCE WITH ARARS

Since there are no promulgated soil cleanup standards, there are no chemical-specific ARARs which can be met by any alternative. Action- and location-specific ARARs are not applicable to this alternative because there are no active remedial actions associated with it.

5.3.4 LONG-TERM EFFECTIVENESS

This alternative would not be expected to achieve the remedial response objectives in the foreseeable future. The concentrations of contaminants would be reduced only by natural attenuation processes.

5.3.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

This alternative would not result in a reduction of contaminant toxicity, mobility, or volume, except that through natural attenuation processes. There would be no removal or treatment of contaminants.

5.3.6 SHORT-TERM EFFECTIVENESS

The risks to workers or the community would not be increased as there would be no remedial activities associated with this alternative. Implementation of this alternative would not result in any adverse environmental impacts. The time required to attain cleanup goals is unknown.

5.3.7 IMPLEMENTABILITY

This alternative can be easily implemented. Construction and maintenance activities are not associated with this alternative. SARA reviews would be performed at 5-year intervals.

5.3.8 COST

The estimated present-worth cost of this alternative, evaluated for a design-life of 30 years is $27,400. No capital costs were included in this estimate. This cost estimate represents O&M costs for the 5-year SARA review only. A breakdown of the line items contributing to the total cost is presented in Table 5-1.

5.4 EVALUATION OF ALTERNATIVE S2 – INSTITUTIONAL ACTIONS

5.4.1 DESCRIPTION

The institutional action alternative does not attempt to remediate contaminated soils, but does provide institutional controls consisting of upgraded site security and deed restrictions. Upgraded site security would include maintaining an existing security fence encompassing the MTL site to minimize the potential for direct human contact with contaminated soils.

Deed restrictions would also be imposed at the MTL site to minimize the potential for routine direct human contact with contaminated areas on-site under the future-use scenarios. Deed restrictions would limit the future use of the MTL site by prohibiting the following actions:

- Residential use of the MTL property.
- Unauthorized excavation and/or disposal of site soils.

This alternative would also include a SARA review at 5-year intervals. As part of the review, new soil sampling and analysis data may be collected if deemed appropriate.

5.4.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative does not attempt to remediate contamination in soil at MTL. There would continue to be residual risk to human health and the environment from

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Table 5-1

Estimated O&M Costs for Alternative S1: No Action

Item	Description	Annual Quantity (Yrs 1-30)	Unit Cost ($)	Cost/Yr (Yrs 1-30) ($)
1	SARA Review	1 per 5 yrs	5,000/review	1,000
2	Administration and Profit (15%)			150
3	Contingency (25%)			250
4	**Total**			1,400

contaminants left in place in site soils. This alternative does not protect the environment in any way, but does provide for some protection of human health. Institutional controls, proposed in this alternative, would mitigate the risk of direct human contact with on-site soils; therefore, this alternative would adequately protect human health as long as institutional controls remained in place and were properly enforced. There would be no reduction in risk to environmental receptors. There would be no additional risks to workers or the community by implementing this alternative. The magnitude of risk would only be lessened by the reduction of contaminants as a result of natural attenuation and degradation processes over the long term.

5.4.3 COMPLIANCE WITH ARARS

Since there are no promulgated soil cleanup standards, there are no chemical-specific ARARs which can be met by any alternative. Action- specific ARARs are not applicable to this alternative because there are no active remedial actions associated with it. Installation of fences would comply with all location-specific ARARs.

5.4.4 LONG-TERM EFFECTIVENESS

This alternative does provide for upgraded security and deed restrictions pertaining to the site. These institutional controls would diminish the risk of direct human contact with contaminated soils on-site; however, contaminated soils will not be treated or contained under this alternative, and therefore, no reduction of contaminants is expected except through natural degradation processes. The long-term effectiveness of this alternative is heavily dependent upon the enforcement of site deed and access restrictions. Any future workers entering the site would be subjected to the same risks as would be present under the no action alternative. No contaminated material is recycled, reused, or destroyed by this alternative.

5.4.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

This alternative would not result in a reduction of contaminant toxicity, mobility, or volume, except that through natural attenuation processes. There would be no removal or treatment of contaminants.

5.4.6 SHORT-TERM EFFECTIVENESS

As with the no action alternative, the risks to workers or the community would not be increased as there would be no remedial activities associated with this alternative. Implementation of this alternative would not result in adverse environmental impacts. The time required to attain soil cleanup goals is unknown.

5.4.7 IMPLEMENTABILITY

This alternative can be easily implemented. Construction and maintenance activities are minimal with this alternative. SARA reviews would be performed at 5-year intervals.

5.4.8 COST

The estimated present-worth cost of this alternative, evaluated for a design-life of 30 years is $178,600. Capital costs are estimated at $12,000. Associated O&M costs are estimated at $8,500, including the costs for the 5-year SARA review. The O&M present worth is estimated at $166,600. A breakdown of the line items contributing to the capital cost is presented in Table 5-2. A breakdown of the O&M costs is presented in Table 5-3.

5.5 EVALUATION OF ALTERNATIVE S3 – CAPPING OF SOILS

5.5.1 DESCRIPTION

The capping alternative consists of installing an asphalt cap over the discrete areas where contaminated soils have been identified in the zones for commercial or residential reuse. These areas are shown in Figures 3-1 to 3-3. The asphalt cap conceptual design is presented in Figure 5-1. The objective of the asphalt cap is to function as a physical barrier that would prevent direct human contact with contaminated soils. This cap is not intended to provide an impermeable layer that would prevent the infiltration of surface runoff, since infiltration and leaching of contaminants are not a concern. There is no evidence that the soil contaminants of concern are migrating to groundwater since these contaminants are not present in significant concentration in groundwater; therefore, mitigating risks posed by these soils can consist of simply preventing direct human contact. Further, the soils at MTL requiring remediation are not a hazardous waste if they remain in place. Based on soil data, if the soil was to be classified as a hazardous waste, it would most likely be TCLP characteristic for chlordane. However, since chlordane was only used at MTL for lawn and garden maintenance, the soil remaining in place does not meet the definition of solid waste under 40 CFR 261.2, hence it is not a hazardous waste. If the same soil is excavated and is found to exceed TCLP characteristics, the excavated soil would be considered hazardous.

Construction of an asphalt cap would require that each area to be capped first be cleared of any obstructions. The ground surface would then be scraped to remove the top 6 inches of ground cover (i.e., grass and roots). Materials generated by this process would be tested and disposed off-site in an acceptable manner. Exposed soils will be moistened and compacted before the cap is installed using conventional construction techniques. Any buildings standing in the areas of concern would be left intact, and the asphalt layer would be connected to the existing foundation. Because of the small areas and shallow slopes of the individual caps, uncontrolled surface water runoff is not anticipated to be a problem.

Table 5-2

Estimated Capital Costs for Alternative S2: Institutional Actions

Legal administration and deed restrictions	$5,000
Provide and install two 6-ft x 10-ft signboards	$3,000
Subtotal	$8,000
Engineering procurement, administrative, and legal costs (20%)	$1,600
Subtotal	$9,600
Contingency (25%)	$2,400
Total	$12,000

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Table 5-3

Estimated O&M Costs for Alternative S2: Institutional Actions

Item	Description	Annual Quantity (Yrs 1-30)	Unit Cost ($)	Cost/Yr (Yrs 1-30) ($)
1	Maintenance of signboards	Lump sum	100	100
2	Maintenance of fence and gates, and access restrictions	Lump sum	5,000	5,000
3	SARA Review	1 per 5 yrs	5,000/review	1,000
4	**Subtotal**			6,100
5	Administration and Profit (15%)			915
6	Contingency (25%)			1,525
7	**Total** (Rounded)			8,500

Stormwater runoff could be channeled into the existing stormwater sewers. Each capped area would first be graded to provide positive drainage. The cap would require maintenance and repair as needed to ensure its continued integrity.

This alternative also includes institutional actions, such as deed restrictions, to prohibit land use activities that would threaten the integrity of the cap. No site work would be performed that could result in damage to the cap. A SARA review would also be performed every five years.

5.5.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The capping alternative adequately protects human health and the environment by preventing direct contact with contaminated soils exceeding cleanup goals. Contaminated soils remain in place under this alternative. Cleanup goals may eventually be achieved, but only through natural attenuation processes over the long term.

This alternative is not anticipated to have any negative impacts on workers or the community. As some contaminated soil could be transported off-site, there is a potential risk of a release during transportation to the disposal facility (e.g., traffic accident).

After the cap installation, there should be no unacceptable risk on-site as long as the cap is properly maintained.

5.5.3 COMPLIANCE WITH ARARS

Since there are no promulgated soil cleanup goals, there are no chemical-specific ARARs which can be met. This alternative would comply with location-specific ARARs. Cap construction involves intrusive work (e.g., excavation). If artifacts are encountered, the involvement of archaeologists and state and federal agencies will be required. Capping would not be done in floodplain areas. This alternative will also comply with action-specific ARARs. All excavated soil would be analyzed for characteristics of hazardous waste. Any hazardous waste would be disposed in accordance with state hazardous waste requirements and federal land disposal restrictions. Nonhazardous soil may be used as backfill on-site.

5.5.4 LONG-TERM EFFECTIVENESS

This alternative does not reduce the levels of contaminated material at the site nor does it reuse, recycle, or destroy contaminants. The contaminants remain in place at the site. The alternative does prevent direct human contact with the contaminated soils and, therefore, reduces the risk. This alternative would be a permanent solution as long as the cap was properly maintained. Any actual reduction in contaminant concentrations would occur through natural attenuation and degradation.

The long-term effectiveness of this alternative depends on maintaining the cap integrity throughout its lifetime. Repair and maintenance will be required periodically. Institutional actions prohibiting intrusive work in capped areas must be properly enforced.

5.5.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

This alternative would not result in a reduction of contaminant toxicity, mobility, or volume, except through natural attenuation processes. There would be no removal or treatment of contaminants. The cap would only prevent contact with the soil contaminants.

5.5.6 SHORT-TERM EFFECTIVENESS

The implementation of this alternative uses ordinary construction techniques and is not anticipated to have any negative impacts on workers or the community. Workers will be health and safety trained in compliance with OSHA regulations. Erosion and sedimentation controls as well as dust controls would be implemented as necessary during cap construction. The implementation of this alternative would not increase the risk to the environment. It is estimated that this alternative would take 7 to 10 months to implement — 3 to 6 months for design and 1 to 3 months to construct based on fair weather conditions.

5.5.7 IMPLEMENTABILITY

Asphalt capping uses conventional construction techniques. It is anticipated that the areas to be capped would require minimal regrading. Implementation of this alternative should not pose any technical difficulties. Materials for construction would be readily available and no special services would be required. After construction, the cap would be periodically inspected for signs of damage or deterioration. Repairs would be performed as necessary.

Under this alternative, the site can be reused for commercial or residential purposes; however, new construction would be limited to areas where the cap was not present, as the integrity of the cap must not be violated by any new activities. This may limit the reuse applications of the site. No people, businesses, or utilities would require relocation from implementation of this alternative.

5.5.8 COST

Alternative S3 would be relatively inexpensive to implement. Capital costs and associated O&M costs for each site reuse scenario are presented in Tables 5-4 to 5-9. For costing purposes, disposal of contaminated material is priced for nonhazardous waste disposal, although the final classification of the hazardous characteristics of the soil will not be performed until implementation and the possibility of hazardous soil disposal costs exist.

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Table 5-4

Estimated Capital Costs for Alternative S3: Capping of Soils — Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate top 6 inches of grass, roots, and soil; transport and stage excavated material on-site (Area = 200,700 ft^2)	3,720 yd^3	13.60/yd^3	50,592
2	Sampling and analysis of excavated soil	15 samples	2,000/ sample	30,000
3	Transport and dispose of contaminated material as nonhazardous waste in a landfill (3,720 yd^3 @ 1.4 tons/yd^3 = 5,208 tons)	5,208 tons	65/ton	338,520
4	Prepare and pave excavated areas	22,300 yd^2	40.50/yd^2	903,150
5	Other site restoration issues and landscaping	lump sum	30,000	30,000
6	Erosion and sediment control	lump sum	45,000	45,000
7	Surveys and drawings	lump sum	15,000	15,000
8	Permitting	lump sum	30,000	30,000
9	Health and safety	175 days	750/day	131,250
10	Construction air monitoring	lump sum	10,000	10,000
11	Mobilization and demobilization	lump sum	70,000	70,000
12	Legal administration and deed restrictions	lump sum	5,000	5,000
13	**Subtotal**			1,658,512
14	Engineering, procurement, administrative, and legal costs (20%)			331,702
15	**Subtotal**			1,990,214
16	Government construction management (7.5%)			149,266
17	Contingency (25%)			497,554
18	**Total** (Rounded)			2,657,000

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Table 5-5

Estimated O&M Costs for Alternative S3: Capping of Soils — Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost (Yrs 1-30) ($)	Total Cost Per Year (Yrs 1-30) ($)
1	Materials and labor for maintenance of the cap (3% of the capital cost)	lump sum	79,111	79,111
2	SARA Review	1 per 5 yrs	5,000/review	1,000
3	**Subtotal**			80,111
4	Administration and Profit (15%)			12,017
5	Contingency (25%)			20,028
6	**Total** (Rounded)			112,000

Table 5-6

Estimated Capital Costs for Alternative S3: Capping of Soils — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate top 6 inches of grass, roots, and soil; transport and stage excavated material on-site (Area = 245,700 ft^2)	4,550 yd^3	13.60/yd^3	61,880
2	Sampling and analysis of excavated soil	19 samples	2,000/ sample	38,000
3	Transport and dispose of contaminated material as nonhazardous waste in a landfill (4,550 yd^3 @ 1.4 tons/yd^3 = 6,370 tons)	6,370 tons	65/ton	414,050
4	Prepare and pave excavated areas	27,300 yd^2	40.50/yd^2	1,105,650
5	Other site restoration issues and landscaping	lump sum	42,000	42,000
6	Erosion and sediment control	lump sum	63,000	63,000
7	Surveys and drawings	lump sum	21,000	21,000
8	Permitting	lump sum	30,000	30,000
9	Construction air monitoring	lump sum	10,000	10,000
10	Health and safety	252 days	750/day	189,000
11	Mobilization and demobilization	lump sum	70,000	70,000
12	Legal administration and deed restrictions	lump sum	5,000	5,000
13	**Subtotal**			2,049,580
14	Engineering, procurement, administrative, and legal costs (20%)			409,916
15	**Subtotal**			2,459,496
16	Government construction management (7.5%)			184,462
17	Contingency (25%)			614,874
18	**Total** (Rounded)			3,259,000

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Table 5-7

Estimated O&M Costs for Alternative S3: Capping of Soils — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost (Yrs 1-30) ($)	Total Cost Per Year (Yrs 1-30) ($)
1	Materials and labor for maintenance of the cap (3% of the capital cost)	lump sum	97,770	97,770
2	SARA Review	1 per 5 yrs	5,000/review	1,000
3	**Subtotal**			98,770
4	Administration and Profit (15%)			14,816
5	Contingency (25%)			24,692
6	**Total** (Rounded)			138,000

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Table 5-8

Estimated Capital Costs for Alternative S3: Capping of Soils — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate top 6 inches of grass, roots, and soil; transport and stage excavated material on-site (Area = 200,700 ft^2)	3,720 yd^3	13.60/yd^3	50,592
2	Sampling and analysis of excavated soil	15 samples	2,000/ sample	30,000
3	Transport and dispose of contaminated material as nonhazardous waste in a landfill (3,720 yd^3 @ 1.4 tons/yd^3 = 5,208 tons)	5,208 tons	65/ton	338,520
4	Prepare and pave excavated areas	22,300 yd^2	40.50/yd^2	903,150
5	Other site restoration issues and landscaping	lump sum	30,000	30,000
6	Erosion and sediment control	lump sum	45,000	45,000
7	Surveys and drawings	lump sum	15,000	15,000
8	Permitting	lump sum	30,000	30,000
9	Health and safety	175 days	750/day	131,250
10	Construction air monitoring	lump sum	10,000	10,000
11	Mobilization and demobilization	lump sum	70,000	70,000
12	Legal administration and deed restrictions	lump sum	5,000	5,000
13	**Subtotal**			1,658,512
14	Engineering, procurement, administrative, and legal costs (20%)			331,702
15	**Subtotal**			1,990,214
16	Government construction management (7.5%)			149,266
17	Contingency (25%)			497,554
18	**Total** (Rounded)			2,657,000

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Table 5-9

Estimated O&M Costs for Alternative S3: Capping of Soils — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost (Yrs 1-30) ($)	Total Cost Per Year (Yrs 1-30) ($)
1	Materials and labor for maintenance of the cap (3% of the capital cost)	lump sum	79,111	79,111
2	SARA Review	1 per 5 yrs	5,000/review	1,000
3	**Subtotal**			80,111
4	Administration and Profit (15%)			12,017
5	Contingency (25%)			20,028
6	**Total** (Rounded)			112,000

5.6 EVALUATION OF ALTERNATIVE S4 – SOIL EXCAVATION AND THERMAL TREATMENT

5.6.1 DESCRIPTION

This alternative involves excavation of contaminated soils, destruction of contaminants using thermal treatment, and backfilling of excavations with clean/treated soils. Three thermal options are evaluated. Option A involves on-site incineration, using a rotary kiln incinerator permitted to treat hazardous soils. Option B involves hauling soils to an off-site commercial hazardous waste incineration facility. Option C involves an on-site low-temperature thermal desorption unit to process the soils. Each option is described below.

The tentative areas of contaminated soil for each site reuse scenario are shown in Figures 3-1 to 3-3; however, since the exact extent of contamination is unknown at this time, the soils will need to be excavated in stages. Excavation would be initiated at a location where soil contamination has been identified by previous sampling and would extend outward until clean soils are found. For example, the initial excavation would cover a given area and extend to just below the deepest location where contamination was detected. The need for continued excavation would be determined by a confirmatory sampling program. Samples would be collected from the bottom and sidewalls of the excavation once it was believed that cleanup goals had been achieved. An on-site laboratory would be used to provide immediate turnaround analysis using EPA-approved methods for samples collected from the excavation to determine if the cleanup goals had been achieved in the excavation. Soil would be stockpiled on-site until treatment is implemented. Any stockpiling would be designed and implemented in compliance with state hazardous waste regulations for waste piles. Stockpiles could be used in several different ways. Soil could be stockpiled in a central on-site location outside; this stockpile would be placed on a foundation, be covered at all times except when waste is being added, and be equipped with leachate collection and runon/runoff controls. Alternatively, soil could be placed in self-contained lined units, such as roll-off containers, with top covering. No leachate collection or runon/runoff controls would be required for self-contained units. Also, soil could be placed in a secure lined area inside an on-site building. This type of location would not need leachate collection or runon/runoff controls. The alternative cost estimates include costs for proper stockpiling as part of the unit cost for excavation, transporting, and staging soil.

The excavations would remain open during the confirmational sampling program. Excavation and treatment actions would be coordinated such that the time frame between soil excavation and treatment was minimized. This will also minimize the time that excavations are left open after the completion of soil removal. Erosion and sedimentation controls would be implemented to prevent migration of soil contaminants.

This alternative also includes institutional controls for any contaminated soil remaining in place underneath buildings. The buildings provide a barrier to contact, and no remediation of these soils is needed as long as the building remains in place. Controls

will be placed in the form of deed restrictions to prohibit the demolition of any buildings with contaminated soil underneath the foundation. A SARA review at 5-year intervals would be conducted for the soil areas covered by the institutional controls.

5.6.1.1 Option A — On-Site Incineration

An on-site incinerator would be a vendor-supplied system. A typical rotary kiln incinerator is depicted in Figure 5-2. A rotary kiln is a cylindrical, refractory-lined shell mounted at a slight incline from the horizontal. This cylinder is rotated to facilitate oxidation of wastes and to promote transfer of wastes through the reactor. A rotary kiln incineration system includes the waste feed system, the rotary kiln incinerator where kiln temperatures reach 1,800 °F, the auxiliary fuel feed system, an afterburner that destroys gaseous products produced within the kiln at temperatures of 2,000 °F, and air pollution control systems. On-site rotary kilns can process soils at rates ranging from 1 to 5 tons per hour (tph) for small units up to 20 tph for large units.

The treated soils (ash) will be moistened and backfilled on-site for Option A. The liquids generated by scrubbing the flue gas will require off-site disposal at an approved facility. On-site incineration will require a trial burn to ensure that required burn efficiencies were being achieved before full-scale operations can begin, and extensive monitoring of stack gases through the duration. As a Superfund remedial measure, a site permit is not required, however the burn efficiency of 99.9999% for operation is required. An air emission permit is also not required, but the air emissions must meet air quality standards. On-site staging facilities for untreated and treated soils are also required. Ash from the incinerator can be used as backfill in the excavations if it has been sampled and analyzed and found not to exceed the soil cleanup standards. Ash would be sampled at a frequency of one sample per 250 cubic yards. It is assumed that 85% of the original soil weight is lost by the incineration, therefore additional clean soil would be necessary to complete backfilling. Alternatively, the ash can be disposed off-site with the excavations backfilled with imported clean fill. Reused ash and clean backfill would be placed in the excavations, compacted, and graded. A 6-inch layer of top soil would be used to complete the backfill process. The backfilled excavation would then be resurfaced and revegetated (or covered with asphalt if the excavation was within a road or parking lot).

5.6.1.2 Option B — Off-Site Incineration

Excavated soils are loaded into trucks and transported to an approved commercial incinerator permitted to accept bulk contaminated soils. Prior to transport, the soil would be analyzed to determine its classification as a hazardous or nonhazardous waste. For conservatism, it is assumed that the soils would be sent to a hazardous waste incinerator; this is based on soil data which indicate that at least some of soil may be TCLP characteristic for chlordane. This is also because nonhazardous waste incinerators generally do not accept soil due to a low BTU content. At MTL, the lowest cost for off-site incineration was provided by Clean Harbors Environmental Services, Inc., of South Boston, MA. Soils to be incinerated would be transported from the site by truck to local rail service. The waste would then be transported by rail to the Clean

Harbors operated incinerator in Kimball, NE. There are not sufficient PCB concentrations in the soil to warrant a need for a TSCA-approved incinerator. A TSCA-approved facility is required for PCB concentrations greater than 50 ppm; MTL soil does not contain PCB levels anywhere near these levels as the highest PCB concentration detected on-site was less than 5 ppm (PCBs were not detected consistently in the soil).

As part of the quoted unit price, the commercial off-site incinerator will landfill the treated soils (ash) and will treat the liquids generated by scrubbing the flue gas. Excavations at the MTL site will be backfilled with imported clean fill. Clean backfill would be placed in the excavations, compacted, and graded. A 6-inch layer of top soil would be used to complete the backfill process. The backfilled excavation would then be resurfaced and revegetated (or covered with asphalt if the excavation was within a road or parking lot).

5.6.1.3 Option C — On-Site Low-Temperature Thermal Desorption

Low-temperature thermal desorption separates organic contaminants from soil by uniformly heating the soil to temperatures high enough to cause the contaminants to desorb (i.e., to diffuse to the surface of the soil particles and then vaporize). Water contained in the soil is also vaporized. A general process flow diagram is presented in Figure 5-3. The fundamental difference between thermal desorption and incineration is that desorption physically separates organic contaminants from the soil, whereas incineration oxidizes and destroys the contaminants and all other organic matter in the soil. Thermal desorption units operate at temperatures lower than incinerators (typically 400 °F to 1,200 °F, whereas incinerators operate at greater than 1,000 °F). Depending upon the treatment temperature within the thermal desorption unit and the organic contaminants present, some contaminant degradation and combustion can occur.

Currently there are several dozen commercially available thermal desorption units, and each uses a slightly different method to heat and mix the soil and to treat the off-gases. Heating methods include direct contact (where the soil contacts the flame) and indirect contact. Mixing methods include rotary drum, rotating augers, and pug mill. Some units operate with adequate oxygen to allow combustion of contaminants, whereas others operate under oxygen-starved conditions to prevent combustion and simplify off-gas treatment. Some units use nitrogen to remove off-gases from the heating chamber, while others recycle stack gases. For off-gas treatment, some units use an afterburner to destroy the contaminants. Other units cool the gases to condense the water and organic vapors. Water is separated and both liquid phases are collected for treatment and disposal. Gases leaving the condenser are typically sent to vapor-phase granular-activated carbon units prior to venting to the atmosphere. Other equipment that can be used includes particulate removal units such as cyclone separators or baghouses.

The primary factors that determine a unit's ability to remove organic contaminants are the soil treatment temperatures and the heating chamber residence time. To remove the heavier organic contaminants present at MTL (PAHs, pesticides, and PCBs), the

soil would require treatment temperatures of 750 °F or greater. A treatability study and a demonstration test would be required to determine optimal operating conditions prior to field application. As with on-site incineration, no permits would be required for a Superfund remediation, but the system must be operated in compliance with any applicable permit conditions. The treated soil would be tested to ensure that soil cleanup goals were achieved prior to on-site backfilling. Treated soil would be sampled at a frequency of one sample per 250 yd^3. It is assumed that none of the original soil weight is lost by the thermal desorption, therefore no additional clean soil (other than top soil) would be necessary to complete backfilling. Reused soil would be placed in the excavations, compacted, and graded. A 6-inch layer of imported top soil would be used to complete the backfill process. The backfilled excavation would then be resurfaced and revegetated (or covered with asphalt if the excavation was within a road or parking lot). Any air emissions would be controlled so as not to violate air quality standards.

5.6.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative will permanently eliminate the threats to human health and the environment presented by the contaminated soils of concern. During excavation, sampling and analysis would be performed to confirm that all necessary material was removed. During excavation, air monitoring would be conducted to determine if there was any potential risk from airborne contaminants. Soil will be excavated from the site until cleanup goals have been achieved. Soil treatment by incineration or thermal desorption would be successful, having been widely used to treat soils contaminated with organic compounds. On-site or off-site incineration would destroy the contaminants of concern. Thermal desorption would remove the contaminants from the soil; the removed contaminants would be incinerated on-site and destroyed or taken off-site for treatment. For on-site treatment options, the treated soil (or ash) will be sampled and analyzed to ensure treatment goals have been achieved. All options of this alternative are equally effective and after completion of remedial actions, the site risks will be consistent with risks resulting from background levels of contaminants.

5.6.3 COMPLIANCE WITH ARARS

All options of this alternative will comply with ARARs. Since there are no promulgated soil cleanup goals, there are no chemical-specific ARARs which can be met.

Location-specific ARARs will be complied with. As this alternative involves intrusive work (excavation), if artifacts are found, the involvement of archaeologists and state and federal agencies will be required. No construction would be done in floodplain areas.

The operations of the various options of this alternative will comply with action-specific ARARs. Any hazardous waste would be managed in accordance with state hazardous waste regulations and, if applicable, federal land disposal restrictions. Any on-site treatment systems will have performance monitoring and any required air emission control. Air emissions will comply with air quality requirements.

5.6.4 LONG-TERM EFFECTIVENESS

All options of this alternative would achieve a permanent solution at the site. The incineration options would destroy the organic contaminants. Thermal desorption would separate the contaminants from the soil; the separated contaminants in liquid or vapor phase would be treated or destroyed separately. The on-site treatment options would reuse the treated soil on-site for backfill. All options of this alternative would reduce site contaminant levels to those that approach background. The magnitude of residual risk would be that the remaining contaminants in soil would be present only at background concentrations. No long-term management, maintenance, or operations would be required.

5.6.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

Incineration and thermal desorption are common technologies with high success rates. Optimal operating conditions that would treat the soil to achieve necessary goals would be determined prior to full-scale field activities. Incineration would destroy the contaminants; thermal desorption would remove them from the soil and be treated further. Either way, contaminant levels remaining in the soil would be at or below cleanup goals. On-site incineration and thermal desorption would be carefully monitored to ensure treatment goals were met and that proper air emission standards were also met.

Treatment residuals from on-site incineration would be any contaminants removed during air emission controls. The removed contaminants from thermal desorption are the treatment residuals; they may be treated on-site or off-site. Off-site incineration has no on-site residuals to manage because contaminated soil is transported to the off-site incinerator.

Both incineration and thermal desorption processes are irreversible. The toxicity, mobility, and volume of contaminants would be virtually eliminated.

5.6.6 SHORT-TERM EFFECTIVENESS

Soil excavation is performed using standards techniques. All site workers would be trained in health and safety in compliance with OSHA requirements. During soil excavation and stockpiling, erosion and sedimentation as well as dust controls would be implemented. There would be a short-term risk to site workers because of the potentially large number of excavations that would remain open. This alternative would be managed to minimize the time between soil removal and excavation backfilling.

The on-site treatment system for Options A or C would need to be constructed in a location to minimize potential disturbance of the community. No significant risk to the community would be expected from the operation of a properly functioning on-site incinerator or thermal desorber. For Option B (off-site incineration), the effect on the

community would consist of heavy truck traffic to transport contaminated soil off-site and to import clean soils for backfilling. This option also has the minor risk of a release of contaminated soil during transportation (e.g., traffic accident).

This alternative removes contaminants from the soil and either destroys them on-site or transports them off-site for destruction. There would be no significant impact to the environment from excavation and incineration, or thermal treatment.

The on-site incineration and thermal desorption options of this alternative are anticipated to take approximately 1 year to 18 months to implement after the design, test runs, and regulatory approval phases are completed. Off-site incineration is anticipated to require 9 months for transportation to the off-site facility.

5.6.7 IMPLEMENTABILITY

Incineration and thermal desorption are proven technologies, and any option can be readily implemented at MTL. Approved excavation and sampling methods will ensure that all of the contaminated soil is removed and treated. Soils treated on-site will be tested prior to backfilling to verify the effectiveness of the treatment process. On-site incineration or desorption also requires test burns to establish efficiency and operating conditions.

Incineration and thermal desorption are not technically complex operations, although they include treatment for off-gases, which may include several different unit operations. There are many commercially available incineration and thermal desorption processes. Off-site incinerators also exist and are readily available. Specially trained operators may be required for an on-site incinerator or thermal desorber; however, the vendor should be able to provide the necessary personnel for operation.

The principal difficulty in on-site incineration or thermal desorption is obtaining regulatory approval for operation of the system. While no permit is required for a Superfund remediation, the system must operate under the conditions that a permit would impose. Test runs for the incinerator or desorber must be performed to ensure that the system will operate according to required specifications. These test runs and the system design may need special approval from EPA or MADEP prior to full-scale operation. There may be a lengthy time period to design and perform test runs on the system as well as the time lag in obtaining agency approval.

While off-site incineration does not have this problem, its principal implementation difficulty would be in obtaining approval from an off-site incinerator to receive the contaminated soil. Because of incinerator backlog, it may take several months to schedule acceptance to the incinerator.

5.6.8 COST

Capital costs for Option A for each site reuse scenario are presented in Tables 5-10 to 5-12, for Option B in Tables 5-13 to 5-15, and for Option C in Tables 5-16 to 5-18.

The only O&M costs associated with any option of this alternative are costs for the 5-year SARA review because of its relatively short duration for actual remedial actions. Table 5-19 presents the estimated annual O&M costs for Options A, B, or C for this alternative.

On-site incineration or thermal desorption is generally more cost-effective for large soil volumes, whereas off-site incineration is preferable for small soil volumes. The break-even soil volume is on the order of 4,000 to 6,000 yd^3. This quantity is not based solely on quoted system costs, but also considers the minimum project size to pay for the high fixed costs of the test burns, foundations, mobilization, etc. Additionally, the quantity considers the fact that even the smallest on-site incinerator or desorber requires approximately 1,000 yd^3 of soil just for the trial burn.

For cost estimating purposes, the level of health and safety personal protective equipment was assumed to be Level C.

5.7 EVALUATION OF ALTERNATIVE S5 – SOIL EXCAVATION, ON-SITE PHYSICAL/CHEMICAL TREATMENT, AND ON-SITE BACKFILLING

5.7.1 DESCRIPTION

This alternative involves the excavating contaminated soils, treating soils using on-site chemical treatment, and backfilling with treated soils. Two different chemical treatment options are evaluated. Option A involves chemical oxidation as the treatment whereby the contaminants are destroyed by chemical reaction. Option B involves solvent extraction whereby the soils are contacted with a solvent that removes contaminants from the soil by transferring them to the solvent. Each option is described below.

The tentative areas of contaminated soil for each site reuse scenario are shown in Figures 3-1 to 3-3; however, since the exact extent of contamination is unknown at this time, the soils will need to be excavated in stages. Excavation would be initiated at a location where soil contamination has been identified by previous sampling and would extend outward until clean soils are found. For example, the initial excavation would cover a given area and extend to just below the deepest location where contamination was detected. The need for continued excavation would be determined by a confirmatory sampling program. Samples would be collected from the bottom and sidewalls of the excavation once it was believed that cleanup goals had been achieved. An on-site laboratory would be used to provide immediate turnaround analysis using EPA-approved methods for samples collected from the excavation to determine if the cleanup goals had been achieved in the excavation. Soil would be stockpiled on-site until treatment is implemented. Any stockpiling would be designed and implemented

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Table 5-10

Estimated Capital Costs for Alternative S4 — Option A: Soil Excavation, Treatment Using On-Site Incineration, and On-Site Backfilling — Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site incineration:			
	• Trial burn and air permitting	lump sum	600,000	600,000
	• Thermal treatment unit foundations, soils staging areas, mobilization/ demobilization	lump sum	1,500,000	1,500,000
	• Incineration (rotary kiln option)	22,300 yd^3	220/yd^3	4,906,000
	• Ash sampling and analysis	14 samples	2,000/sample	28,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Incineration activities	166 days	750/day	124,500
7	Excavation delineation sampling, mobile laboratory	108 days	2,000 /day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization (other than incinerator)	lump sum	18,000	18,000
11	Institutional actions for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			7,987,252
13	Engineering, procurement, administrative, and legal costs (20%)			1,597,450
14	**Subtotal**			9,584,702
15	Government construction management (7.5%)			718,852
16	Contingency (25%)			2,396,176
17	**Total** (Rounded)			12,700,000

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Table 5-11

Estimated Capital Costs for Alternative S4 — Option A: Soil Excavation, Treatment Using On-Site Incineration, and On-Site Backfilling — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	27,300 yd^3	13.60/yd^3	371,280
2	On-site incineration:			
	• Trial burn and air permitting	lump sum	600,000	600,000
	• Thermal treatment unit foundations, soils staging areas, mobilization/demobilization	lump sum	1,500,000	1,500,000
	• Incineration (rotary kiln option)	27,300 yd^3	220/yd^3	6,006,000
	• Ash sampling and analysis	17 samples	2,000/sample	34,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	27,300 yd^3	4.60/yd^3	125,580
	• Import and place topsoil, 6 inches thick	4,550 yd^3	13.80/yd^3	62,790
	• Seeding and mulching, revegetation	27,300 yd^2	0.72/yd^2	19,656
4	Other restoration issues and landscaping	lump sum	10,000	10,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	124 days	750/day	93,000
	• Incineration activities	190 days	750/day	142,500
7	Excavation delineation sampling, mobile laboratory	124 days	2,000 /day	248,000
8	Erosion and sediment controls	lump sum	14,000	14,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization (other than incinerator)	lump sum	21,000	21,000
11	Institutional controls for contaminated soil under buildings	lump sum	5,000	5,000
12	**Subtotal**			9,270,306
13	Engineering, procurement, administrative, and legal costs (20%)			1,854,061
14	**Subtotal**			11,124,367
15	Government construction management (7.5%)			834,328
16	Contingency (25%)			2,781,092
17	**Total** (Rounded)			14,740,000

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Table 5-12

Estimated Capital Costs for Alternative S4 — Option A: Soil Excavation, Treatment Using On-Site Incineration, and On-Site Backfilling — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site incineration:			
	• Trial burn and air permitting	lump sum	600,000	600,000
	• Thermal treatment unit foundations, soils staging areas, mobilization/ demobilization	lump sum	1,500,000	1,500,000
	• Incineration (rotary kiln option)	22,300 yd^3	220/yd^3	4,906,000
	• Ash sampling and analysis	14 samples	2,000/sample	28,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Incineration activities	166 days	750/day	124,500
7	Excavation delineation sampling, mobile laboratory	108 days	2,000 /day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization (other than incinerator)	lump sum	18,000	18,000
11	Institutional actions for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			7,987,252
13	Engineering, procurement, administrative, and legal costs (20%)			1,597,450
14	**Subtotal**			9,584,702
15	Government construction management (7.5%)			718,852
16	Contingency (25%)			2,396,176
17	**Total** (Rounded)			12,700,000

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Table 5-13

Estimated Capital Costs for Alternative S4 – Option B: Soil Excavation, Treatment Using Off-Site Incineration, and On-Site Backfilling – Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	Off-site incineration:			
	• Transportation, incineration, and ash disposal (22,300 yd^3 @ 1.4 tons/yd^3 = 31,220 tons)	31,220 tons	900 /ton	28,098,000
3	Backfill excavated areas:			
	• Import and place clean soils at excavated areas, grade and contour	22,300 yd^3	16.11/yd^3	359,253
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
7	Excavation delineation sampling, mobile laboratory	108 days	2,000 /day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	18,000	18,000
11	Institutional controls for contaminated soil under buildings	lump sum	5,000	5,000
12	**Subtotal**			29,183,425
13	Engineering, procurement, administrative, and legal costs (20%)			5,836,685
14	**Subtotal**			35,020,110
15	Government construction management (7.5%)			2,626,508
16	Contingency (25%)			8,755,028
17	**Total** (Rounded)			46,402,000

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Table 5-14

Estimated Capital Costs for Alternative S4 — Option B: Soil Excavation, Treatment Using Off-Site Incineration, and On-Site Backfilling — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	27,300 yd^3	13.60/yd^3	371,280
2	Off-site incineration:			
	• Transportation, incineration, and ash disposal (27,300 yd^3 @ 1.4 tons/yd^3 = 38,220 tons)	38,220 tons	900 /ton	34,398,000
3	Backfill excavated areas:			
	• Import and place clean soils at excavated areas, grade and contour	27,300 yd^3	16.11/yd^3	439,803
	• Import and place topsoil, 6 inches thick	4,550 yd^3	13,80/yd^3	62,790
	• Seeding and mulching, revegetation	27,300 yd^2	0.72/yd^2	19,656
4	Other restoration issues and landscaping	lump sum	10,000	10,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	124 days	750/day	93,000
7	Excavation delineation sampling, mobile laboratory	124 days	2,000 /day	248,000
8	Erosion and sediment controls	lump sum	14,000	14,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	21,000	21,000
11	Institutional controls for contaminated soil under buildings	lump sum	5,000	5,000
12	**Subtotal**			35,700,029
13	Engineering, procurement, administrative, and legal costs (20%)			7,140,006
14	**Subtotal**			42,840,035
15	Government construction management (7.5%)			3,213,003
16	Contingency (25%)			10,710,009
17	**Total** (Rounded)			56,763,000

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Table 5-15

Estimated Capital Costs for Alternative S4 – Option B: Soil Excavation, Treatment Using Off-Site Incineration, and On-Site Backfilling – Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	Off-site incineration:			
	• Transportation, incineration, and ash disposal (22,300 yd^3 @ 1.4 tons/yd^3 = 31,220 tons)	31,220 tons	900 /ton	28,098,000
3	Backfill excavated areas:			
	• Import and place clean soils at excavated areas, grade and contour	22,300 yd^3	16.11/yd^3	359,253
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
7	Excavation delineation sampling, mobile laboratory	108 days	2,000 /day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	18,000	18,000
11	Institutional controls for contaminated soil under buildings	lump sum	5,000	5,000
12	**Subtotal**			29,183,425
13	Engineering, procurement, administrative, and legal costs (20%)			5,836,685
14	**Subtotal**			35,020,110
15	Government construction management (7.5%)			2,626,508
16	Contingency (25%)			8,755,028
17	**Total** (Rounded)			46,402,000

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Table 5-16

Estimated Capital Costs for Alternative S4 — Option C: Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling — Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site thermal desorption:			
	• Treatability study	lump sum	20,000	20,000
	• Preparation of project plans and analysis system	lump sum	250,000	250,000
	• Trial burn and air permitting	lump sum	300,000	300,000
	• Thermal treatment unit foundations, soils staging areas, mobilization/ demobilization	lump sum	400,000	400,000
	• Soil and off-gas treatment cost	22,300 yd^3	360/yd^3	8,028,000
	• Confirmational soil analysis	90 samples	2,000/sample	180,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Thermal desorption activities	123 days	750/day	92,250
7	Excavation delineation sampling, mobile laboratory	108 days	2,000 /day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization (other than desorber)	lump sum	18,000	18,000
11	Institutional controls for contaminated soils under buildings	lump sum	5,000	5,000
12	**Subtotal**			10,099,002
13	Engineering, procurement, administrative, and legal costs (20%)			2,019,800
14	**Subtotal**			12,118,802

Table 5-16

Estimated Capital Costs for Alternative S4 — Option C: Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling — Site Reuse Scenario 1 (Continued)

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
15	Government construction management (7.5%)			908,910
16	Contingency (25%)			3,029,701
17	**Total** (Rounded)			16,057,000

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Table 5-17

Estimated Capital Costs for Alternative S4 — Option C: Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	27,300 yd^3	13.60/yd^3	371,280
2	On-site thermal desorption:			
	• Treatability study	lump sum	20,000	20,000
	• Preparation of project plans and analysis system	lump sum	250,000	250,000
	• Trial burn and air permitting	lump sum	300,000	300,000
	• Thermal treatment unit foundations, soils staging areas, mobilization/ demobilization	lump sum	400,000	400,000
	• Soil and off-gas treatment cost	27,300 yd^3	360/yd^3	9,828,000
	• Confirmational soil analysis	109 samples	2,000/sample	218,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	27,300 yd^3	4.60/yd^3	125,580
	• Import and place topsoil, 6 inches thick	4,550 yd^3	13.80/yd^3	62,790
	• Seeding and mulching, revegetation	27,300 yd^2	0.72/yd^2	19,656
4	Other restoration issues and landscaping	lump sum	10,000	10,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	124 days	750/day	93,000
	• Thermal desorption activities	139 days	750/day	104,250
7	Excavation delineation sampling, mobile laboratory	124 days	2,000/day	248,000
8	Erosion and sediment controls	lump sum	14,000	14,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization (other than desorber)	lump sum	21,000	21,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			12,108,056
13	Engineering, procurement, administrative, and legal costs (20%)			2,421,611
14	**Subtotal**			14,529,667

Table 5-17

Estimated Capital Costs for Alternative S4 — Option C: Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling — Site Reuse Scenario 2 (Continued)

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
14	**Subtotal**			14,529,667
15	Government construction management (7.5%)			1,089,725
16	Contingency (25%)			3,632,417
17	**Total** (Rounded)			19,252,000

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Table 5-18

Estimated Capital Costs for Alternative S4 — Option C: Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site thermal desorption:			
	• Treatability study	lump sum	20,000	20,000
	• Preparation of project plans and analysis system	lump sum	250,000	250,000
	• Trial burn and air permitting	lump sum	300,000	300,000
	• Thermal treatment unit foundations, soils staging areas, mobilization/ demobilization	lump sum	400,000	400,000
	• Soil and off-gas treatment cost	22,300 yd^3	360/yd^3	8,028,000
	• Confirmational soil analysis	90 samples	2,000/sample	180,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Thermal desorption activities	123 days	750/day	92,250
7	Excavation delineation sampling, mobile laboratory	108 days	2,000 /day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting (other than air)	lump sum	7,500	7,500
10	Mobilization/demobilization (other than desorber)	lump sum	18,000	18,000
11	Institutional controls for contaminated soils under buildings	lump sum	5,000	5,000
12	**Subtotal**			10,099,002
13	Engineering, procurement, administrative, and legal costs (20%)			2,019,800
14	**Subtotal**			12,118,802

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Table 5-18

Estimated Capital Costs for Alternative S4 — Option C: Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling — Site Reuse Scenario 3 (Continued)

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
15	Government construction management (7.5%)			908,910
16	Contingency (25%)			3,029,701
17	**Total** (Rounded)			16,057,000

Table 5-19

Estimated O&M Costs for Alternative S4: Options A Through C

Item	Description	Annual Quantity (Yrs 1-30)	Unit Cost ($)	Cost/Yr (Yrs 1-30) ($)
1	SARA Review	1 per 5 yrs	5,000/review	1,000
2	Administration and Profit (15%)			150
3	Contingency (25%)			250
4	**Total**			1,400

in compliance with state hazardous waste regulations for waste piles. Stockpiles could be used in several different ways. Soil could be stockpiled in a central on-site location outside; this stockpile would be placed on a foundation, be covered at all times except when waste is being added, and be equipped with leachate collection and runon/runoff controls. Alternatively, soil could be placed in self-contained lined units, such as roll-off containers, with top covering. No leachate collection or runon/runoff controls would be required for self-contained units. Also, soil could be placed in a secure lined area inside an on-site building. This type of location would not need leachate collection or runon/runoff controls. The alternative cost estimates include costs for proper stockpiling as part of the unit cost for excavation, transporting, and staging soil.

The excavations would remain open during the conformational sampling program. Excavation and treatment actions would be coordinated such that the time frame between soil excavation and treatment was minimized. This will also minimize the time that excavations are left open after the completion of soil removal. Erosion and sedimentation controls would be implemented to prevent migration of soil contaminants. It would be preferable to have all excavated soil staged in a centrally located, lined, and bermed stockpile area. The stockpile would be covered when not in use for extended periods of time.

This alternative also includes institutional controls for any contaminated soil remaining in place underneath buildings. The buildings provide a barrier to contact, and no remediation of these soils is needed as long as the building remains in place. Controls will be placed in the form of deed restrictions to prohibit the demolition of any buildings with contaminated soil underneath the foundation. A SARA review at 5-year intervals would be conducted for the soil areas covered by the institutional controls.

5.7.1.1 <u>Option A — Chemical Oxidation</u>

The chemical oxidation process, as developed by Solids Management, Inc., involves a proprietary chemical oxidizing agent (a mixture of inorganic oxides and silicates). Prior to field application, soil samples would be analyzed to determine the proper oxidizing reagent dosage required to obtain the cleanup goals.

In the process, as shown in Figure 5-4, contaminated soil is first screened to break up large pieces of soil into smaller pieces and to remove large rocks and debris. The soil is then loaded into the feed hopper, weighed, deposited onto the main conveyor, and conveyed to the mixer reactor. The speed of the system would be set to achieve the optimum mixing time of the three required components: soil, water, and oxidizing reagent. The reagent hopper would be mounted directly over the main conveyor. The automatic, variable-speed control on the reagent hopper is set to supply the required percentage of predetermined reagent directly onto the soil as it travels along the main conveyor to the mixer.

As the reagent and soil are deposited into the mixer, a predetermined quantity of water would be added. The process requires water addition of 5% to 10% of the soil weight. An on-site water source would be used to supply the water needs. Groundwater

(contaminated or uncontaminated) or river water could be used to supply the reaction. In the mixer reactor, the components are thoroughly mixed to disperse the reagent throughout the mixture. The reagent would oxidize and destroy the organic contaminants. There would be no air emissions from the reactor.

As more material enters the mixer, the material already present would be displaced and would exit the mixer. The displaced soil would be deposited at a staging area for stockpiling. After 24 hours, each stockpile (approximately 250 yd^3) would be sampled and analyzed for confirmation that the soil has been successfully treated. If any soil were to fail the analysis, the entire pile would be treated again. The treatment system is mobile and can treat 800 to 1,000 tons of soil per day. There is no liquid stream from the reactor that requires separate treatment. While oxidizing agent residues may be present in the treated soils, the residues are not harmful to human health or the environment.

Processed soils, which have been verified to meet the treatment standards, will be backfilled on-site. No additional clean soil (other than top soil) would be necessary to complete backfilling. Reused soil would be placed in the excavations, compacted, and graded. A 6-inch layer of imported top soil would be used to complete the backfill process. The backfilled excavation would then be resurfaced and revegetated (or covered with asphalt if the excavation was within a road or parking lot).

5.7.1.2 Option B — Solvent Extraction

The solvent extraction process involves contacting the contaminated soils with a solvent that will transfer the contaminants from the soil into the solvent. The basic process is offered by several vendors, each using a different solvent. The key to solvent extraction at MTL is to use a solvent that is not harmful to human health and the environment, since treated soil may contain residual amounts of solvent.

Some examples of existing solvent extraction vendors include Resources Conservation Company, which offers the B.E.S.T.® solvent extraction system using triethylamine as the solvent; Terra-Kleen Corporation, which uses a proprietary environmentally nontoxic solvent; and CF Systems Corporation, whose process uses liquified gases (propane, carbon dioxide, etc.) as solvents. Prior to field application of this technology at MTL, bench-scale or pilot-scale testing would be necessary to determine which available process would work best with site soil and contaminants.. Current literature on these processes indicates they could be implemented successfully at MTL.

A basic solvent extraction process flow diagram is shown in Figure 5-5. The diagram for a specific vender process may be different. The first step in the process, as with chemical oxidation, is screening to break up large pieces of soil and to remove large rocks and debris. Screened soil is sent to the extractor, where the soil is mixed with the solvent. The extractor could be operated in a batch or counter-current mode. Treated soil, as well as contaminated solvent, exits the extractor. The solvent is sent to the solvent recovery system to be purified and recycled. The recovery system produces solvent that is sent back to the extractor and a small quantity of waste solvent

that contains the removed contaminants. This waste solvent is sent off-site for treatment and disposal. Fresh solvent is added as make-up to the extractor.

The treated soil would be deposited at a staging area for stockpiling. Each stockpile (approximately 250 yd^3) would be sampled and analyzed for confirmation that the soil has been successfully treated. If any soil were to fail the analysis, the entire pile would be treated again. The treatment system can treat 150 tons of soil per day. The treated soils may contain solvent residues; however, the residues are not harmful to human health or the environment.

Processed soils, which have been verified to meet the treatment standards, will be backfilled on-site. No additional clean soil (other than top soil) would be necessary to complete backfilling. Reused soil would be placed in the excavations, compacted, and graded. A 6-inch layer of imported top soil would be used to complete the backfill process. The backfilled excavation would then be resurfaced and revegetated (or covered with asphalt if the excavation was within a road or parking lot).

5.7.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative will permanently eliminate the threats to human health and the environment presented by the contaminated soils. During excavation, sampling and analysis would be performed to confirm that all soil with contaminants exceeding cleanup goals was removed. During excavation, air monitoring would be conducted to determine if there was any potential risk from airborne contaminants. Soil will be excavated from the site until cleanup goals have been achieved. For the treatment steps, prior to field application, bench- or pilot-scale tests would be performed to determine which particular treatment process could best handle the soil and achieve treatment goals.

The chemical oxidation process has no residuals to manage. The treated soil may contain excess unreacted reagent as well as reaction breakdown products. However, there is no risk to human health or the environment from this since both the oxidizing reagent and its breakdown products are nontoxic. Solvent extraction has a waste solvent stream that requires separate off-site treatment and disposal. Solvent extraction will also result in residual concentrations of solvent remaining in the treated soil; this is not of concern since the solvent is not harmful to human health or the environment. Both options of this alternative are equally effective and after completion of remedial actions, the site risks will be consistent with risks resulting from background levels of contaminants. The treatment options in this alternative will be operated such that proper treatment is achieved. The treated soil will be sampled and analyzed to ensure treatment goals have been achieved.

5.7.3 COMPLIANCE WITH ARARS

Both options of this alternative will comply with ARARs. Since there are no promulgated soil cleanup goals, there are no chemical-specific ARARs to be met.

Location-specific ARARs will be complied with. As this alternative involves intrusive work (excavation), if artifacts are found, the involvement of archaeologists and state and federal agencies will be required. Treatment units will not be located within floodplain areas.

The operations of the options of this alternative will comply with action-specific ARARs. Any hazardous wastes would be managed in accordance with state hazardous waste regulations and, if applicable, federal land disposal restrictions. Any on-site treatment systems will have performance monitoring and any required monitoring control. Removed contaminants from the solvent extraction would be properly handled prior to subsequent treatment and/or disposal.

5.7.4 LONG-TERM EFFECTIVENESS

Both options of this alternative would achieve a permanent solution and would reduce contaminant levels to those approaching background. The magnitude of residual risk would be that the remaining contaminants in soil would be present only at background concentrations. The soil cleanup goals would be met both in the excavation during soil removal and by the treatment options of this alternative. The soil would only be backfilled on-site after it was verified that treatment goals were achieved. Any soil not meeting the cleanup goals would be reprocessed until the cleanup goals were met. Both options reuse the soil on-site after it has been successfully treated. Chemical oxidation would destroy the contaminants. Solvent extraction would transfer the contaminants into the solvent. The waste solvent would then require separate treatment and disposal. No long-term management, maintenance, or operations would be required.

5.7.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

Chemical oxidation and solvent extraction are proven technologies. The soil is contacted with either a nontoxic oxidizing agent to destroy organic contaminants or a nontoxic solvent to remove the organics from the soil. Either way, contaminant levels remaining in the soil would be at or below cleanup goals. Optimal operating conditions that would treat the soil to achieve necessary goals would be determined prior to full-scale field activities.

Oxidation would result in destruction of the organic contaminants. The treatment residuals would be unreacted oxidizing agent or agent breakdown products. Both the agent and its breakdown products are nonharmful so no additional treatment would be required. Unreacted agent would lead to the presence of calcium oxides and silicates in the soil. A result of the oxidation reaction would be a slightly higher soil pH as a result of the formation of calcium hydroxide.

Solvent extraction would not destroy contaminants but separate them from the soil. A concentrated solution of waste solvent would require further treatment and/or disposal. The extraction process may also leave behind trace quantities of solvent in the treated soil, depending on the type of solvent. The B.E.S.T.® process would result

in the presence of triethylamine in the soil. However, the solvent is nontoxic and no further treatment would be required. The CF Systems process would not leave residuals in the soil because supercritical gases are used for the solvent.

Both the oxidation and solvent extraction processes are irreversible. Oxidation would eliminate the toxicity, mobility, and volume of contaminants via contaminant destruction. Solvent extraction would reduce the volume and would eliminate their mobility by separating them from the soil. Contaminant toxicity would only be reduced from off-site treatment of residual contaminated solvent.

5.7.6 SHORT-TERM EFFECTIVENESS

Soil excavation is performed using standards techniques. All site workers would be trained in health and safety in compliance with OSHA requirements. During soil excavation and stockpiling, erosion and sedimentation as well as dust controls would be implemented. There would be a short-term risk to site workers because of the potentially large number of excavations that would remain open. This alternative would be managed to minimize the time between soil removal and excavation backfilling.

Because of the industrial nature of the area, truck traffic to and from the site is not expected to cause a negative impact on the community. This alternative would result in much less truck traffic than some of the other alternatives because there would be no need for off-site transportation of soil, although some transport of treatment residuals off-site would be necessary for the solvent extraction option. Both treatment system options are mobile and can be placed on-site in an area that would minimize potential disturbance of the community.

This alternative removes contaminants from the soil or destroys them on-site. Implementation would not result in adverse impacts to the environment. Based on the soil properties, it may be necessary to repeat treatment to achieve the cleanup goals. Confirmatory analysis will be taken for each batch of treated soil to verify treatment effectiveness.

The soil excavation for this alternative is anticipated to take approximately 6 months. Chemical oxidation treatment is estimated to take 2 months, and solvent extraction is estimated to take 6 months. Prior to full-scale implementation, pilot or bench-scale tests will be required. These are estimated to take 2 to 4 months for test completion and full-scale design and operation.

5.7.7 IMPLEMENTABILITY

Implementation of either option of this alternative is relatively straightforward. Excavation uses common remedial techniques. Approved excavation and sampling methods will ensure that all of the contaminated soil is removed and treated. The treated soil will be tested on-site prior to backfilling to verify the effectiveness of the treatment process. Any soil not meeting cleanup goals would be reprocessed until the

goals were met. Prior to full-scale operation, bench and/or pilot-scale tests will be performed as needed to determine optimal system operation conditions to meet cleanup goals.

The solvent extraction process is more technically complex than oxidation; however, both options are proven technologies. Both options require open space to set up treatment and staging areas; such open space is available on-site. The operation of either treatment system should not interfere with any other site operations.

Since proprietary systems would be used for either oxidation or solvent extraction, the specific process would only be available from a single vendor. Equipment for the oxidation process is common equipment and would be easily obtained from common sources; however, the system would require the use of a particular vender who offers the proprietary oxidizing agent. Solvent extraction is offered by several vendors, each using a different solvent with different properties. Each process is proprietary and would only be available through the one particular vendor.

5.7.8 COST

This alternative using either option would be less costly than other treatment alternatives. The capital costs between chemical oxidation and solvent extraction vary considerably with oxidation being more economical, partially as a result of the higher initial setup and mobilization costs required for solvent extraction. The capital costs for chemical oxidation for each site reuse scenario are presented in Tables 5-20 to 5-22. The costs for solvent extraction for each site reuse scenario are presented in Tables 5-23 to 5-25. For cost estimating purposes, the level of health and safety personal protective equipment was assumed to be Level C.

The only O&M costs associated with either option of this alternative are costs for the 5-year SARA review because of the relatively short duration of implementation of remedial actions. Table 5-26 presents an estimate of the annual O&M costs for either option of this alternative.

5.8 EVALUATION OF ALTERNATIVE S6 — SOIL EXCAVATION AND OFF-SITE DISPOSAL OR REUSE

5.8.1 DESCRIPTION

This alternative proposes the excavation of contaminated on-site soils and subsequent reuse or disposal of the soils in an approved off-site facility. The off-site facility could be one or more of the following options: hazardous waste landfill, nonhazardous waste landfill, landfill daily cover, and asphalt-batching plant. The determination of which of the options is to be used will heavily depend on the soil characterization including a hazardous waste determination for excavated soils. Nonhazardous soil could be disposed in a nonhazardous landfill or be reused as landfill daily cover or by an asphalt-batching plant. Hazardous soil under this alternative would only be disposed in a hazardous waste landfill.

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Table 5-20

Estimated Capital Costs for Alternative S5 — Option A: Soil Excavation, Treatment Using Chemical Oxidation, and On-Site Backfilling — Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site chemical oxidation soil treatment:			
	• Pretreatment soil testing (reagent dosage determination)	lump sum	20,000	20,000
	• Soil screening	46 days	200/day	9,200
	• Soil treatment cost	22,300 yd^3	95/yd^3	2,118,500
	• Confirmational soil analysis	90 samples	2,000/sample	180,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Soil treatment activities	46 days	750/day	34,500
7	Excavation delineation sampling, mobile laboratory	108 days	2,000/day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	10,000	10,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			3,182,952
13	Engineering, procurement, administrative, and legal costs (20%)			636,590
14	**Subtotal**			3,819,542
15	Government construction management (7.5%)			286,466
16	Contingency (25%)			954,886
17	**Total** (Rounded)			5,061,000

Table 5-21

Estimated Capital Costs for Alternative S5 — Option A: Soil Excavation, Treatment Using Chemical Oxidation, and On-Site Backfilling — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	27,300 yd^3	13.60/yd^3	371,280
2	On-site chemical oxidation soil treatment:			
	• Pretreatment soil testing (reagent dosage determination)	lump sum	20,000	20,000
	• Soil screening	60 days	200/day	12,000
	• Soil treatment cost	27,300 yd^3	95/yd^3	2,593,500
	• Confirmational soil analysis	109 samples	2,000/sample	218,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	27,300 yd^3	4.60/yd^3	125,580
	• Import and place topsoil, 6 inches thick	4,550 yd^3	13.80/yd^3	62,790
	• Seeding and mulching, revegetation	27,300 yd^2	0.72/yd^2	19,656
4	Other restoration issues and landscaping	lump sum	10,000	10,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	124 days	750/day	93,000
	• Soil treatment activities	60 days	750/day	45,000
7	Excavation delineation sampling, mobile laboratory	124 days	2,000/day	248,000
8	Erosion and sediment controls	lump sum	14,000	14,000
9	Permitting	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	14,000	14,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			3,869,306
13	Engineering, procurement, administrative, and legal costs (20%)			773,861
14	**Subtotal**			4,643,167
15	Government construction management (7.5%)			348,238
16	Contingency (25%)			1,160,792
17	**Total** (Rounded)			6,152,000

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Table 5-22

Estimated Capital Costs for Alternative S5 — Option A: Soil Excavation, Treatment Using Chemical Oxidation, and On-Site Backfilling — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site chemical oxidation soil treatment:			
	• Pretreatment soil testing (reagent dosage determination)	lump sum	20,000	20,000
	• Soil screening	46 days	200/day	9,200
	• Soil treatment cost	22,300 yd^3	95/yd^3	2,118,500
	• Confirmational soil analysis	90 samples	2,000/sample	180,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Soil treatment activities	46 days	750/day	34,500
7	Excavation delineation sampling, mobile laboratory	108 days	2,000/day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	10,000	10,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			3,182,952
13	Engineering, procurement, administrative, and legal costs (20%)			636,590
14	**Subtotal**			3,819,542
15	Government construction management (7.5%)			286,466
16	Contingency (25%)			954,886
17	**Total** (Rounded)			5,061,000

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Table 5-23

Estimated Capital Costs for Alternative S5 – Option B: Soil Excavation, Treatment Using Solvent Extraction, and On-Site Backfilling – Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site solvent extraction soil treatment:			
	• Bench- and pilot-scale testing	lump sum	40,000	40,000
	• Treatment unit foundations, mobilization/ demobilization	lump sum	50,000	50,000
	• Soil treatment cost	22,300 yd^3	250/yd^3	5,575,000
	• Waste disposal	6,500 lbs	0.25/lb	1,625
	• Confirmational soil analysis	90 samples	2,000/sample	180,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Soil treatment activities	144 days	750/day	108,000
7	Excavation delineation sampling, mobile laboratory	108 days	2,000/day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	10,000	10,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			6,775,377
13	Engineering, procurement, administrative, and legal costs (20%)			1,355,075
14	**Subtotal**			8,130,452
15	Government construction management (7.5%)			609,784
16	Contingency (25%)			2,032,613
17	**Total** (Rounded)			10,773,000

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Table 5-24

Estimated Capital Costs for Alternative S5 — Option B: Soil Excavation, Treatment Using Solvent Extraction, and On-Site Backfilling — Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	27,300 yd^3	13.60/yd^3	371,280
2	On-site solvent extraction soil treatment:			
	• Bench- and pilot-scale testing	lump sum	40,000	40,000
	• Treatment unit foundations, mobilization/ demobilization	lump sum	50,000	50,000
	• Soil treatment cost	27,300 yd^3	250/yd^3	6,825,000
	• Waste Disposal	8,500 lbs	0.25/lb	2,125
	• Confirmational soil analysis	109 samples	2,000/sample	218,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	27,300 yd^3	4.60/yd^3	125,580
	• Import and place topsoil, 6 inches thick	4,550 yd^3	13.80/yd^3	62,790
	• Seeding and mulching, revegetation	27,300 yd^2	0.72/yd^2	19,656
4	Other restoration issues and landscaping	lump sum	10,000	10,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	124 days	750/day	93,000
	• Soil treatment activities	185 days	750/day	138,750
7	Excavation delineation sampling, mobile laboratory	124 days	2,000/day	248,000
8	Erosion and sediment controls	lump sum	14,000	14,000
9	Permitting	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	14,000	14,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			8,254,681
13	Engineering, procurement, administrative, and legal costs (20%)			1,650,936
14	**Subtotal**			9,905,617
15	Government construction management (7.5%)			742,922
16	Contingency (25%)			2,476,404
17	**Total** (Rounded)			13,125,000

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Table 5-25

Estimated Capital Costs for Alternative S5 — Option B: Soil Excavation, Treatment Using Solvent Extraction, and On-Site Backfilling — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated soil	22,300 yd^3	13.60/yd^3	303,280
2	On-site solvent extraction soil treatment:			
	• Bench- and pilot-scale testing	lump sum	40,000	40,000
	• Treatment unit foundations, mobilization/ demobilization	lump sum	50,000	50,000
	• Soil treatment cost	22,300 yd^3	250/yd^3	5,575,000
	• Waste disposal	6,500 lbs	0.25/lb	1,625
	• Confirmational soil analysis	90 samples	2,000/sample	180,000
3	Backfill excavated areas:			
	• Place treated soils at excavated areas, grade and contour	22,300 yd^3	4.60/yd^3	102,580
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety:			
	• Excavation	108 days	750/day	81,000
	• Soil treatment activities	144 days	750/day	108,000
7	Excavation delineation sampling, mobile laboratory	108 days	2,000/day	216,000
8	Erosion and sediment controls	lump sum	10,000	10,000
9	Permitting	lump sum	7,500	7,500
10	Mobilization/demobilization	lump sum	10,000	10,000
11	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
12	**Subtotal**			6,775,377
13	Engineering, procurement, administrative, and legal costs (20%)			1,355,075
14	**Subtotal**			8,130,452
15	Government construction management (7.5%)			609,784
16	Contingency (25%)			2,032,613
17	**Total** (Rounded)			10,773,000

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Table 5-26

Estimated O&M Costs for Alternative S5: Options A and B

Item	Description	Annual Quantity (Yrs 1-30)	Unit Cost ($)	Cost/Yr (Yrs 1-30) ($)
1	SARA Review	1 per 5 yrs	5,000/review	1,000
2	Administration and Profit (15%)			150
3	Contingency (25%)			250
4	**Total**			1,400

The tentative areas of contaminated soil for each site reuse scenario are shown in Figures 3-1 to 3-3; however, since the exact extent of contamination is unknown at this time, the soils will need to be excavated in stages. Excavation would be initiated at a location where soil contamination has been identified by previous sampling and would extend outward until clean soils are found. For example, the initial excavation would cover a given area and extend to just below the deepest location where contamination was detected. The need for continued excavation would be determined by a confirmatory sampling program. Samples would be collected from the bottom and sidewalls of the excavation once it was believed that cleanup goals had been achieved. An on-site laboratory would be used to provide immediate turnaround analysis using EPA-approved methods for samples collected from the excavation to determine if the cleanup goals had been achieved in the excavation. Soil would be stockpiled on-site until treatment is implemented. Any stockpiling would be designed and implemented in compliance with state hazardous waste regulations for waste piles. Stockpiles could be used in several different ways. Soil could be stockpiled in a central on-site location outside; this stockpile would be placed on a foundation, be covered at all times except when waste is being added, and be equipped with leachate collection and runon/runoff controls. Alternatively, soil could be placed in self-contained lined units, such as roll-off containers, with top covering. No leachate collection or runon/runoff controls would be required for self-contained units. Also, soil could be placed in a secure lined area inside an on-site building. This type of location would not need leachate collection or runon/runoff controls. The alternative cost estimates include costs for proper stockpiling as part of the unit cost for excavation, transporting, and staging soil.

The excavations would remain open during the conformational sampling program. Excavation and treatment actions would be coordinated such that the time frame between soil excavation and treatment was minimized. This will also minimize the time that excavations are left open after the completion of soil removal. Erosion and sedimentation controls would be implemented to prevent migration of soil contaminants. It would be desired to have all excavated soil staged in a centrally located, lined, and bermed stockpile area. The stockpile would be covered when not in use for extended periods of time. Trucks for off-site transportation would have easy access to the pile for loading soil.

Prior to off-site transportation, soils would need to be sampled and analyzed for TCLP constituents at a minimum. Further characterization of contaminated soils will likely be required by the facility where the soil is to be reused or disposed. Soils will be characterized prior to transportation off-site. Transportation of contaminated soils from MTL to the receiving facility will be conducted by a licensed hauler and will comply with state and federal regulations. For transportation, truck routes will be established to minimize the impact on local traffic.

It is anticipated that approximately 50% of the excavated soil would be classified as hazardous because of chlordane toxicity (TCLP). Soil that is a hazardous waste may require treatment to comply with Land Disposal Restriction regulations prior to placement in the landfill if the levels are in excess of the Universal Treatment Standard for chlordane under Land Disposal Restrictions. The Universal Treatment Standard

for chlordane is 0.26 ppm (total); if this standard is exceeded, then treatment would be required prior to land disposal. This treatment, if required, would be provided by the disposal facility at their location prior to land disposal.

Excavations, after undergoing confirmatory sampling to ensure that all contaminated soil was removed, will be backfilled using clean fill from an off-site source. Clean soil would be placed in the excavations, compacted, and graded. A 6-inch layer of imported top soil would be used to complete the backfill process. The backfilled excavation would then be resurfaced and revegetated (or covered with asphalt if the excavation was within a road or parking lot).

This alternative also includes institutional controls for any contaminated soil remaining in place underneath buildings. The buildings provide a barrier to contact, and no remediation of these soils is needed as long as the building remains in place. Controls will be placed in the form of deed restrictions to prohibit the demolition of any buildings with contaminated soil underneath the foundation. A SARA review at 5-year intervals would be conducted for the soil areas covered by the institutional controls.

5.8.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This alternative will permanently eliminate the threats to human health and the environment presented by the contaminated soils . During excavation, sampling and analysis would be performed to confirm that all necessary material was removed. During excavation, air monitoring would be conducted to determine if there was any potential risk from airborne contaminants. Soil will be excavated from the site until cleanup goals have been achieved. The excavated soil would be transported off-site for disposal or reuse. In either case, this alternative would provide sufficient protection to human health or the environment. Soil reused or disposed in a landfill would be properly managed within the facility. Soil reused in an asphalt batching plant would have contaminants stabilized and immobilized within the asphalt. All options of this alternative are equally effective and after completion of remedial actions, the site risks will be consistent with risks resulting from background levels of contaminants. Excavations will be backfilled with soil from off-site. This backfill material will be confirmed to be clean fill prior to on-site use.

5.8.3 COMPLIANCE WITH ARARS

This alternative will comply with ARARs. Since there are no promulgated soil cleanup goals, there are no chemical-specific ARARs to be met.

Location-specific ARARs will be complied with. Because this alternative involves intrusive work (excavation), if artifacts are found, the involvement of archaeologists and state and federal agencies will be required.

This alternative will comply with action-specific ARARs. The excavated soil will undergo analysis for hazardous waste characteristics. All soil identified as hazardous

will be transported to a hazardous waste landfill. If required, the soil will be treated to conform to land disposal restriction requirements prior to placement in the landfill. Nonhazardous soil can be taken for off-site disposal in a nonhazardous waste landfill or can be reused as daily cover in a landfill or reused at an asphalt-batching plant. The nonhazardous soil will be further characterized as needed to ensure that its contaminant concentrations are within the permit limits of the facility to receive the soil.

5.8.4 LONG-TERM EFFECTIVENESS

This alternative would achieve a permanent solution at the site. This alternative would reduce site contaminant levels to background. The magnitude of residual risk would be that the remaining contaminants in soil would be present only at background concentrations. All contaminated soil would be transported off-site. No long-term management, maintenance, or operations would be required.

5.8.5 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

This alternative, although it does not treat contaminants (unless required to meet land disposal restrictions), will remove contaminated soil from the site and dispose of it in a contained landfill or reuse it as landfill daily cover or in an asphalt-batching facility. As a result, this alternative is expected to reduce the risk of on-site exposure to that which is consistent with background levels of contaminants; however, wastes disposed of in the landfill will require indefinite long-term management.

In this alternative, toxicity and volume of contaminants is not reduced. However, the mobility is significantly reduced. The contaminants are either placed in a secure landfill or are immobilized in asphalt batching.

5.8.6 SHORT-TERM EFFECTIVENESS

Soil excavation is performed using standards techniques. All site workers would be trained in health and safety in compliance with OSHA requirements. During soil excavation and stockpiling, erosion and sedimentation as well as dust controls would be implemented. There would be a short-term risk to site workers because of the potentially large number of excavations that would remain open. This alternative would be managed to minimize the time between soil removal and excavation backfilling.

For this alternative, the effect on the community would consist of heavy truck traffic to transport contaminated soil off-site and to import clean soils for backfilling. This option also has the minor risk of a release of contaminated soil during transportation (e.g., traffic accident).

This alternative removes contaminated soil from the site and transports them off-site for disposal or reuse. Implementation would not result in adverse impacts to the

environment. Reuse of the soil would not reintroduce risk to human health or the environment.

Depending on the scheduling of the off-site disposal facility, this alternative is estimated to require approximately 9 months to implement.

5.8.7 IMPLEMENTABILITY

Implementation of this alternative is straightforward and uses common remedial excavation techniques. Monitoring for airborne contaminants and sampling of the excavation to ensure complete contaminant removal are easily performed. Before excavation is started, a decision will be made as to the optimal desired disposal site(s) for each type of soil. A hazardous landfill will be identified for any hazardous soil removed. For the nonhazardous soils, either a nonhazardous landfill or an asphalt-batching facility will be chosen. These facilities will be contacted as to their permit requirements, their capacities, and their backlog to receive material. Disposal or reuse facilities with insufficient capacity or a long waiting time because of current backlog will not be selected. Facilities will be chosen to minimize the time excavated soils will remain on-site.

This alternative requires no special site preparation. Approved sampling and excavation methods will ensure that all of the contaminated soil is removed. As with Alternatives S3 through S5, excavated soil will be stockpiled on-site and will be covered until transportation. Only common materials are needed to implement this alternative. No special services are needed.

The potential principal difficulty in implementing this alternative is obtaining approvals in a timely fashion from the selected disposal facilities. Because of facility backlog, it may take several months to schedule acceptance at the facility. This is more of a concern for the hazardous soil, since there are no local hazardous waste landfill facilities. There are several different nonhazardous landfills and asphalt-batching plants that could accept soil.

5.8.8 COST

Capital costs for each reuse scenario are presented in Tables 5-27 to 5-29. For cost estimating purposes, the level of health and safety personal protective equipment was assumed to be Level C. The only O&M costs associated with this alternative are costs for the 5-year SARA review because of the relatively short duration of implementation of remedial actions. Table 5-30 presents an estimate of the annual O&M costs for this alternative.

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Table 5-27

Estimated Capital Costs for Alternative S6: Soil Excavation and Off-Site Disposal or Reuse — Site Reuse Scenario 1

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated material	22,300 yd^3	13.60/yd^3	303,280
2	Transport and dispose of excavated material as contaminated waste at a landfill (without stabilization):			
	• Hazardous waste (11,150 yd^3 @ 1.4 tons/yd^3 = 15,610 tons)	15,610 tons	246/ton	3,840,060
	• Nonhazardous waste (11,150 yd^3 @ 1.4 tons/yd^3 = 15,610 tons)	15,610 tons	65/ton	1,014,650
3	Backfill excavated areas:			
	• Import and place clean soil at excavated areas, grade and contour	22,300 yd^3	16.10/yd^3	359,253
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety during excavation	108 days	750/day	81,000
7	Excavation stockpile sampling and analysis	90 samples	2,000/sample	180,000
8	Excavation delineation sampling, mobile laboratory	108 days	2,000/day	216,000
9	Erosion and sediment controls	lump sum	10,000	10,000
10	Permitting	lump sum	7,500	7,500
11	Mobilization/demobilization	lump sum	10,000	10,000
12	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
13	**Subtotal**			6,112,135
14	Engineering, procurement, administrative, and legal costs (20%)			1,222,427
15	**Subtotal**			7,334,562
16	Government construction management (7.5%)			550,092
17	Contingency (25%)			1,833,641
18	**Total** (Rounded)			9,718,000

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Table 5-28

Estimated Capital Costs for Alternative S6: Soil Excavation and Off-Site Disposal or Reuse – Site Reuse Scenario 2

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated material	27,300 yd^3	13.60/yd^3	371,280
2	Transport and dispose of excavated material as contaminated waste at a landfill (without stabilization):			
	• Hazardous waste (13,650 yd^3 @ 1.4 tons/yd^3 = 19,110 tons)	19,110 tons	246/ton	4,701,060
	• Nonhazardous waste (13,650 yd^3 @ 1.4 tons/yd^3 = 19,110 tons)	19,110 tons	65/ton	1,242,150
3	Backfill excavated areas:			
	• Import and place clean soil at excavated areas, grade and contour	27,300 yd^3	16.10/yd^3	439,803
	• Import and place topsoil, 6 inches thick	4,550 yd^3	13.80/yd^3	62,790
	• Seeding and mulching, revegetation	27,300 yd^2	0.72/yd^2	19,656
4	Other restoration issues and landscaping	lump sum	10,000	10,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety during excavation	124 days	750/day	93,000
7	Excavation stockpile sampling and analysis	109 samples	2,000/sample	218,000
8	Excavation delineation sampling, mobile laboratory	124 days	2,000/day	248,000
9	Erosion and sediment controls	lump sum	14,000	14,000
10	Permitting	lump sum	7,500	7,500
11	Mobilization/demobilization	lump sum	14,000	14,000
12	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
13	**Subtotal**			7,456,239
14	Engineering, procurement, administrative, and legal costs (20%)			1,491,248
15	**Subtotal**			8,947,487
16	Government construction management (7.5%)			671,062
17	Contingency (25%)			2,236,872
18	**Total** (Rounded)			11,855,000

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Table 5-29

Estimated Capital Costs for Alternative S6: Soil Excavation and Off-Site Disposal or Reuse — Site Reuse Scenario 3

Item	Description	Quantity	Unit Cost ($)	Total Cost ($)
1	Excavate, transport, and stage contaminated material	22,300 yd^3	13.60/yd^3	303,280
2	Transport and dispose of excavated material as contaminated waste at a landfill (without stabilization):			
	• Hazardous waste (11,150 yd^3 @ 1.4 tons/yd^3 = 15,610 tons)	15,610 tons	246/ton	3,840,060
	• Nonhazardous waste (11,150 yd^3 @ 1.4 tons/yd^3 = 15,610 tons)	15,610 tons	65/ton	1,014,650
3	Backfill excavated areas:			
	• Import and place clean soil at excavated areas, grade and contour	22,300 yd^3	16.10/yd^3	359,253
	• Import and place topsoil, 6 inches thick	3,720 yd^3	13.80/yd^3	51,336
	• Seeding and mulching, revegetation	22,300 yd^2	0.72/yd^2	16,056
4	Other restoration issues and landscaping	lump sum	8,000	8,000
5	Construction air monitoring	lump sum	10,000	10,000
6	Health and safety during excavation	108 days	750/day	81,000
7	Excavation stockpile sampling and analysis	90 samples	2,000/sample	180,000
8	Excavation delineation sampling, mobile laboratory	108 days	2,000/day	216,000
9	Erosion and sediment controls	lump sum	10,000	10,000
10	Permitting	lump sum	7,500	7,500
11	Mobilization/demobilization	lump sum	10,000	10,000
12	Institutional controls for contaminated soil underneath buildings	lump sum	5,000	5,000
13	**Subtotal**			6,112,135
14	Engineering, procurement, administrative, and legal costs (20%)			1,222,427
15	**Subtotal**			7,334,562
16	Government construction management (7.5%)			550,092
17	Contingency (25%)			1,833,641
18	**Total** (Rounded)			9,718,000

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Table 5-30

Estimated O&M Costs for Alternative S6: Soil Excavation and Off-Site Disposal or Reuse

Item	Description	Annual Quantity (Yrs 1-30)	Unit Cost ($)	Cost/Yr (Yrs 1-30) ($)
1	SARA Review	1 per 5 yrs	5,000/review	1,000
2	Administration and Profit (15%)			150
3	Contingency (25%)			250
4	**Total**			1,400

SECTION 6

SUMMARY AND COMPARISON OF ALTERNATIVES

The MTL Outdoor Area FS has been performed in accordance with current CERCLA FS guidance and procedures. In this section, a comparison of the alternatives evaluated in Section 5 is presented with respect to noncost and cost elements. Alternatives analyzed consist of the following:

- Alternative S1 - No Action
- Alternative S2 - Institutional Controls
- Alternative S3 - Capping of Contaminated Soils
- Alternative S4 - Soil Excavation and Thermal Treatment
  - Option A - On-Site Incineration
  - Option B - Off-Site Incineration
  - Option C - Low-Temperature Thermal Desorption
- Alternative S5 - Soil Excavation, On-Site Physical/Chemical Treatment
  - Option A - Chemical Oxidation
  - Option B - Solvent Extraction
- Alternative S6 - Soil Excavation and Off-Site Disposal or Reuse

6.1 NONCOST COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial action alternatives were comparatively evaluated based on the following noncost criteria:

- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness.
- Reduction in toxicity, mobility, and volume of contaminants through treatment.
- Short-term effectiveness.
- Implementability.

The following subsections provide a comparative analysis for the alternatives using each of the analysis criteria for evaluation. The following augments the information presented in Table 6-1 and highlights the advantages, disadvantages, and relative merits of each alternative.

Table 6-1

Noncost Comparison of Soil Alternatives

Criteria	Alternative S1 No Action	Alternative S2 Institutional Controls	Alternative S3 Capping of Soils	Alternative S4 Option A Treatment Using On-Site Incineration	Alternative S4 Option B Treatment Using Off-Site Incineration	Alternative S4 Option C Treatment Using Thermal Desorption	Alternative S5 Option A Treatment Using Chemical Oxidation	Alternative S5 Option B Treatment Using Solvent Extraction	Alternative S6 Off-Site Disposal or Reuse
Overall Protection of Human Health and the Environment									
• Protectiveness	Would fail to achieve remedial action objectives for contaminated soils.	Would fail to achieve remedial action objectives for contaminated soils.	Would protect human health and the environment by preventing direct human contact with risk-based soils.	Would protect human health and the environment by permanently destroying all soil contaminants.	Would protect human health and the environment by permanently destroying all soil contaminants.	Would protect human health and the environment by permanently removing contaminants from site soil.	Would protect human health and the environment by permanently destroying contaminants in site soils.	Would protect human health and the environment by extracting contaminants from soils.	Would protect human health and the environment by removing contaminated soils from the site and disposing them in an approved landfill.
Compliance with ARARs									
• Chemical-Specific	None.	None.	None.	None.	None.	None.	None.	None.	None.
• Location-Specific	Not applicable.	Would meet location-specific ARARs.	Would meet location-specific ARARs.	Would meet location-specific ARARs.	Would meet location-specific ARARs.	Would meet location-specific ARARs.	Would meet location-specific ARARs.	Would meet location-specific ARARs.	Would meet location-specific ARARs.
• Action-Specific	Not applicable.	Not applicable.	Would meet action-specific ARARs.	Would meet action-specific ARARs. Stabilization may be required.	Would meet action-specific ARARs. Stabilization may be required.	Would meet action-specific ARARs.	Would meet action-specific ARARs.	Would meet action-specific ARARs.	Would meet action-specific ARARs. Stabilization may be required.

Table 6-1

Noncost Comparison of Soil Alternatives (Continued)

Criteria	Alternative S1 No Action	Alternative S2 Institutional Controls	Alternative S3 Capping of Soils	Alternative S4 Option A Treatment Using On-Site Incineration	Alternative S4 Option B Treatment Using Off-Site Incineration	Alternative S4 Option C Treatment Using Thermal Desorption	Alternative S5 Option A Treatment Using Chemical Oxidation	Alternative S5 Option B Treatment Using Solvent Extraction	Alternative S6 Off-Site Disposal or Reuse
• Compliance with Other Criteria, Waiver Laws and Guidance	Does not meet remedial response objectives criteria.	Does not meet remedial response objectives criteria.	Meets remedial response objectives criteria.	Meets remedial response objectives criteria.	Meets remedial response objectives criteria.	Meets remedial response objectives criteria.	Meets remedial response objectives criteria.	Meets remedial response objectives criteria.	Meets remedial response objectives criteria.
Long-Term Effectiveness									
• Adequacy and Reliability of Controls	Not applicable.	Not adequate to meet remedial objectives for contaminated soils.	Asphalt cap would require a long-term maintenance commitment and institutional controls.	Soil contaminants will be destroyed by incineration, thereby eliminating the need for long-term controls.	Soil contaminants will be destroyed by incineration, thereby eliminating the need for long-term controls.	Soil contaminants will be removed and treated separately, thereby eliminating the need for long-term controls.	Soil contaminants will be destroyed by chemical oxidation, thereby eliminating the need for long-term controls.	Soil contaminants will be extracted, thereby eliminating the need for long-term controls.	Contaminated soils will be removed from the site; however, disposed soils will have to be managed in a landfill indefinitely.
• Magnitude of Residual Risk	Risk not reduced.	No reduction in risk to environmental receptors.	Residual risk minimized as long as cap is properly maintained.	Risk reduced to background levels of contaminants (within NCP acceptable levels).	Risk reduced to background levels of contaminants (within NCP acceptable levels).	Risk reduced to background levels of contaminants (within NCP acceptable levels).	Risk reduced to background levels of contaminants (within NCP acceptable levels).	Risk reduced to background levels of contaminants (within NCP acceptable levels).	Risk reduced to background levels of contaminants (within NCP acceptable levels).

Table 6-1

Noncost Comparison of Soil Alternatives (Continued)

Criteria	Alternative S1 No Action	Alternative S2 Institutional Controls	Alternative S3 Capping of Soils	Alternative S4 Option A Treatment Using On-Site Incineration	Alternative S4 Option B Treatment Using Off-Site Incineration	Alternative S4 Option C Treatment Using Thermal Desorption	Alternative S5 Option A Treatment Using Chemical Oxidation	Alternative S5 Option B Treatment Using Solvent Extraction	Alternative S6 Off-Site Disposal or Reuse
Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment									
• Treatment Process Used and Materials Treated	Not applicable.	Not applicable.	An asphalt cap will provide a physical barrier preventing direct human contact with risk-based contaminated soils.	Incineration will permanently remove contaminants of concern by thermal destruction.	Incineration will permanently remove contaminants of concern by thermal destruction.	Thermal desorption will permanently remove contaminants from site soil to be treated or destroyed separately.	Chemical oxidation will permanently destroy soil contaminants.	Solvent extraction will permanently remove soil contaminants and subsequently treat them.	Excavation and off-site disposal does not treat or destroy contaminants but will limit their mobility.
• Amount of Hazardous Materials Treated or Destroyed	None.	None.	None.	All soil contaminants of concern will be destroyed.	All soil contaminants of concern will be destroyed.	Soil contaminants of concern will be removed.	Soil contaminants will be permanently destroyed.	Soil contaminants will be extracted from soil and treated.	None. Contaminated soils will not be treated but will be contained.
• Degree of Expected Reduction in Toxicity, Mobility, and Volume	None.	None.	None.	Toxicity, mobility, and volume of contaminants will be virtually eliminated.	Toxicity, mobility, and volume of contaminants will be virtually eliminated.	Toxicity, mobility, and volume of contaminants will be virtually eliminated.	Toxicity, mobility, and volume of contaminants will be significantly reduced.	Toxicity, mobility, and volume of contaminants will be significantly reduced through removal of contaminants from site soil.	Only the mobility of contaminants will be significantly reduced.

Table 6-1

Noncost Comparison of Soil Alternatives (Continued)

Criteria	Alternative S1 No Action	Alternative S2 Institutional Controls	Alternative S3 Capping of Soils	Alternative S4 Option A Treatment Using On-Site Incineration	Alternative S4 Option B Treatment Using Off-Site Incineration	Alternative S4 Option C Treatment Using Thermal Desorption	Alternative S5 Option A Treatment Using Chemical Oxidation	Alternative S5 Option B Treatment Using Solvent Extraction	Alternative S6 Off-Site Disposal or Reuse
• Degree of Irreversibility	Not applicable.	Not applicable.	Completely reversible.	Irreversible.	Irreversible.	Irreversible.	Irreversible.	Irreversible.	Irreversible.
• Type and Quantity of Residuals Remaining	All soil contaminants will remain.	All soil contaminants will remain.	All soil contaminants will remain.	No residual contamination expected to remain.	No residual contamination expected to remain.	No residual contamination expected to remain.	No residual contamination expected to remain.	No residual contamination expected to remain.	No residual contamination expected to remain.
Short-Term Effectiveness									
• Protection of Community During Implementation	Not applicable.	Institutional controls would restrict direct contact with soils.	Erosion and sedimentation as well as dust controls would be implemented during paving operations.	Erosion and sedimentation as well as dust controls would be implemented during excavation. Heavy truck traffic would result.	Erosion and sedimentation as well as dust controls would be implemented during excavation. Heavy truck traffic would result.	Erosion and sedimentation as well as dust controls would be implemented during excavation.	Erosion and sedimentation as well as dust controls would be implemented during excavation.	Erosion and sedimentation as well as dust controls would be implemented during excavation.	Erosion and sedimentation as well as dust controls would be implemented during excavation. Heavy truck traffic would result.
• Protection of Workers	Not applicable.	Not applicable.	Workers would be adequately protected during construction.	Workers would be adequately protected during soil remediation.	Workers would be adequately protected during soil remediation.	Workers would be adequately protected during soil remediation.	Workers would be adequately protected during soil remediation.	Workers would be adequately protected during soil remediation.	Workers would be adequately protected during soil remediation.

Table 6-1

Noncost Comparison of Soil Alternatives (Continued)

Criteria	Alternative S1 No Action	Alternative S2 Institutional Controls	Alternative S3 Capping of Soils	Alternative S4 Option A Treatment Using On-Site Incineration	Alternative S4 Option B Treatment Using Off-Site Incineration	Alternative S4 Option C Treatment Using Thermal Desorption	Alternative S5 Option A Treatment Using Chemical Oxidation	Alternative S5 Option B Treatment Using Solvent Extraction	Alternative S6 Off-Site Disposal or Reuse
Implementability									
• Ability to Construct and Operate the Technology	Not applicable.	Not applicable.	Asphalt capping uses ordinary paving techniques.	Mobile incinerators are widely used and easily constructed and operated. Test burns are required.	Off-site incinerators exist and are easily accessed.	Thermal desorption units are commercially available and easily operated. Pilot tests are required.	Mobile chemical oxidation units can be easily installed and operated.	Solvent extraction units are commercially available and easily installed and operated.	Excavation and off-site disposal can be easily implemented through regular excavation activities.
• Ease of Site Preparation	Not applicable.	Not applicable.	Easily performed.	No site preparation needed.	No site preparation needed.	No site preparation needed.	No site preparation needed.	No site preparation needed.	No site preparation needed.
• Ease of Undertaking Additional Remedial Actions	Not applicable.	Not applicable.	Will not interfere with any additional remedial actions.	Will not interfere with any additional remedial actions.	Will not interfere with any additional remedial actions.	Will not interfere with any additional remedial actions.	Will not interfere with any additional remedial actions.	Will not interfere with any additional remedial actions.	Will not interfere with any additional remedial actions.
• Ability to Monitor Effectiveness	Not applicable.	Not applicable.	Cap will be periodically inspected for signs of deterioration and damage.	Treated soils and site excavations will be tested to ensure that treatment standards are met.	Treated soils and site excavations will be tested to ensure that treatment standards are met.	Treated soils and site excavations will be tested to ensure that treatment standards are met.	Treated soils and site excavations will be tested to ensure that treatment standards are met.	Treated soils and site excavations will be tested to ensure that treatment standards are met.	Confirmatory sampling will ensure complete removal of contaminated soil.

Table 6-1

Noncost Comparison of Soil Alternatives (Continued)

Criteria	Alternative S1 No Action	Alternative S2 Institutional Controls	Alternative S3 Capping of Soils	Alternative S4 Option A Treatment Using On-Site Incineration	Alternative S4 Option B Treatment Using Off-Site Incineration	Alternative S4 Option C Treatment Using Thermal Desorption	Alternative S5 Option A Treatment Using Chemical Oxidation	Alternative S5 Option B Treatment Using Solvent Extraction	Alternative S6 Off-Site Disposal or Reuse
• Ability to Obtain Approval from Other Agencies	Not applicable.	Deed restrictions should not be difficult to obtain.	Approval from the state may be difficult to obtain.	Test burns required to ensure proper operating conditions.	Approval not needed.	Pilot tests required to ensure proper operating conditions.	Approval to operate an on-site chemical oxidation unit should not be difficult to obtain.	Approval to operate an on-site chemical oxidation unit should not be difficult to obtain.	Approval by a landfill may be difficult to obtain.
• Availability of Materials	Not applicable.	Materials for security measures are readily available.	Materials are readily available.	Materials are readily available.	Materials are readily available.	Materials are readily available.	Materials are readily available.	Materials are readily available.	Materials are readily available.
• Availability of Unusual or Special Services	Not applicable.	Not applicable.	Not needed.	Readily available.	Readily available.	Readily available.	Readily available.	Readily available.	Not needed.

6.1.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternatives 1 and 2 do not provide protection for the environment since neither option attempts to remediate contaminated site soil. The only reduction in contaminant concentration under these alternatives is through natural attenuation and degradation. Alternative 1 also does not provide protection against direct human contact with contaminated soils.

Alternative 2 provides a limited amount of protection for human health with the use of deed restrictions and increased site security. This alternative is expected to continue to provide some protection to human health as long as institutional controls are upheld. Alternatives 1 and 2 would not impose additional risks on site workers or the community since neither of these options involve a plan for disrupting site soils.

Alternative 3 provides more protection to human health and the environment than Alternatives 1 and 2. Capping contaminated soils will provide adequate protection to human health and the environment as long as the cap integrity is maintained. Some risk of release may be involved with this alternative if some contaminated soil is transported off-site for disposal.

Alternative 4 provides more protection to human health and the environment by destroying or removing contaminants from the soil. Site soil contaminants would either be removed from the soil by thermal desorption or destroyed by on- or off-site incineration. Contaminants removed by thermal desorption would require additional treatment off-site. For off-site incineration, some risk of release would be involved with transporting contaminated site soil to the incineration location. These options would eliminate any risk associated with contaminated site soils.

Alternative 5 will also eliminate all risk to human health and the environment originating from contaminated site soils. Soils will be treated by chemical oxidation or solvent extraction. Chemical oxidation destroys the contaminants and solvent extraction removes the contaminants from site soil, transferring them to a solvent. Both of these technologies use oxidizers/solvents which are non-toxic to humans and the environment. Following extraction, residual contaminants contained in the solvent will require further treatment off-site. Alternative 5 would remediate site soil to background levels.

Like Alternative 5, Alternative 6 would eliminate any threats from site soil contaminants and would remediate site soil to background levels. If site soil is excavated and reused at an asphalt batching plant, no long-term monitoring would be necessary. However, if contaminated site soil is transported to a landfill disposal facility, long-term monitoring and facility maintenance and security would continue indefinitely.

6.1.2 COMPLIANCE WITH ARARS

There are no chemical-specific ARARs for this site since there are no promulgated soil cleanup standards. All of the alternatives meet the location-specific and action-specific ARARs (if applicable). Alternatives 1 and 2 are the only alternatives that do not achieve remedial response objectives criteria. However, some alternatives may require additional treatment in order to achieve specific characteristics required by treatment or disposal facilities. For example, for Alternative 4, excavated site soil may require stabilization prior to incineration and for Alternative 6, excavated site soils planned for disposal in a hazardous landfill may need further treatment in order to meet the facilities specific soil characteristic requirements.

6.1.3 LONG-TERM EFFECTIVENESS

Alternative 1 would not provide any additional protection of human health and the environment. Alternative 2 will provide some protection against human contact with contaminated soil through deed restrictions and security measures. However, site workers and the environment will not be protected and will be exposed to the same level of risk as in Alternative 1. These two alternatives will not achieve remedial response objectives since contaminants in site soil are not being reduced or removed other than through natural attenuation or degradation.

Alternative 3 provides more long-term protection to human health and the environment than Alternatives 1 and 2. Although this alternative does not remove contaminants from site soil, the possibility of direct human contact is removed by containing contaminated site soils with the construction of an asphalt cap. The asphalt cap will require proper, regular maintenance over its lifetime as well as institutional actions over the long-term to prevent access to capped areas. Risks to human health return if the cap is damaged or removed.

The options available under Alternative 4 are proven and reliable technologies that provide greater long-term protection than Alternative 3. Alternative 4 would be a permanent solution to contamination of site soils. Options under this alternative either destroy the contaminants immediately through incineration, or remove contaminants from site soil by thermal desorption, allowing for transportation and treatment or destruction at an off-site facility. Contaminants will be either destroyed or removed to background levels so that no significant risk will remain and no future maintenance or security activities will be necessary.

Alternative 5 will prove just as effective in providing protection as Alternative 4 and also provides a permanent solution. Site soil contaminants will be either destroyed or transferred from the soil to a solvent and subsequently treated off-site. With these options, treated soil is used as clean fill and backfilled into the site excavations. Long-term maintenance and site security will not be necessary with this alternative.

Alternative 6 will also provide a permanent solution to site soil contamination with no on-site long-term management or security. All contaminated soil would be excavated

and transported to an off-site landfill disposal facility. This remediation technique would leave behind only soil with concentrations of contaminants at background levels. If the site soil is disposed in a landfill facility, transported soil will require monitoring for an indefinite period. If the soil is transported to an asphalt batching plant, contaminants will be immobilized and no monitoring will be necessary.

6.1.4 REDUCTION IN TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS THROUGH TREATMENT

Alternatives 1, 2, and 3 will not reduce the toxicity, mobility, or volume of site soil contaminants. No treatment or removal of contaminants are involved with these alternatives other than through natural attenuation. Although Alternative 3 would prevent direct contact with contaminants during the natural attenuation process, the toxicity, mobility, and volume of contaminants are not affected.

Alternative 4 is an irreversible alternative which will nearly eliminate the toxicity, mobility, and volume of site soil contaminants. The incineration option would destroy the contaminants of concern and the thermal desorption option would remove contaminants from the soil to be treated further. Implementation of Alternative 4 would treat contaminated site soil to clean-up goals or below.

Alternative 5 is also irreversible and very effective in reducing the toxicity, mobility, and volume of site soil contaminants. The oxidation option would destroy soil contaminants, eliminating the toxicity and volume of the contaminants. The solvent extraction option would remove contaminants from site soil and send them off-site for treatment, thereby eliminating the toxicity, mobility, and volume of contaminants.

Alternative 6 significantly reduces the mobility of contaminants in site soil although toxicity and volume are not reduced in the soil transported off-site. Contaminated site soil is excavated from the property and transported off-site for disposal. If transported to a landfill, contaminated site soil will require long-term monitoring. Reuse of site soil in an asphalt batching plant will immobilize contaminants, eliminating the need for such long-term monitoring.

6.1.5 SHORT-TERM EFFECTIVENESS

Alternatives 1 and 2 will not have any significant short-term impacts to human health or the environment since no active remedial measures will be taken.

Measures will be taken during implementation of Alternatives 3 through 6 to protect the community from short-term impacts, including erosion, sedimentation, and dust controls during paving and/or excavation. However, some risk may be imposed on the community because of heavy truck traffic around the site for transportation of incineration, solvent extraction or oxidation equipment to the site, or transport of contaminated soil from the site to the final disposal destination. Workers involved in remediation activities associated with Alternatives 3 through 6 will be 40-hour OSHA

Health and Safety trained and will be protected with appropriate field personal protective equipment (PPE).

There are no foreseeable impacts to the environment from implementation of Alternatives 3 through 6. Any on-site soil staging or treatment units would not be located in environmentally sensitive areas.

Short-term effectiveness also evaluates the time it will take for an alternative to achieve protection. Prior to implementation of any alternative, the Army estimates that the time to complete documents required by the FFA and to complete the procurement process will be approximately 18 to 24 months. Under Alternative 1, protection would not be achieved for many years. Under Alternative 2, protection would be attained when the institutional controls would be in place (approximately 3 months). Protection would be achieved by Alternative 3 through construction of the asphalt cap, which is expected to take approximately 7 to 10 months.

For Alternatives 4 and 5, protection would be attained by either destroying, extracting, or removing site soil contaminants. After design work and pilot tests have been completed, implementation of Alternative 4 is expected to take 1 year to 18 months. Alternative 5 is expected to take approximately 6 to 8 months to implement.

Under Alternative 6, risk to human health will be removed as soon as contaminated soil is excavated and transported off-site. Excavation activities and acceptance at an off-site disposal facility is expected to take approximately 9 months to implement.

6.1.6 IMPLEMENTABILITY

Alternative 1 can be easily implemented because no construction of remediation activities is involved. Alternative 2 can also be easily implemented. Minimal construction and maintenance activities are associated with installing security measures and implementing deed restrictions.

Alternatives 3 and 6 will be more easily implemented than Alternatives 4 and 5. For Alternative 3, standard techniques would be used to construct the asphalt cap and no special permits or equipment would be needed. The cap would need to be inspected and maintained regularly for an indefinite length of time.

For Alternative 6, like Alternative 3, no special services or operating units are needed. Prior to excavation, two disposal facilities will be chosen, one for hazardous and one for nonhazardous soils. Approvals for disposal will be obtained. Soil will be excavated, stockpiled, and transported to the designated off-site facilities. Excavations will be sampled to confirm the removal of contaminated site soil to nearly background levels. Acceptance of site soil to a specific disposal site may take several months.

Alternatives 4, 5, and 6 will employ routine excavation and air monitoring techniques that are readily implemented at the start of the remediation activities. Alternative 4 will be more technically difficult to implement at the MTL site than Alternative 3.

Incineration and thermal desorption will include several unit operations. These incineration and thermal desorption units are commercially available through many vendors and obtaining these units will be fairly easy. Although actual permits are not required for operation of these units, they must demonstrate the capability of operating within substantive permit standards required by various federal and state agencies. Obtaining approval from the agencies to operate the chosen technology or scheduling and obtaining approval for treatment at an off-site incinerator may take more than a few months.

Like Alternative 4, Alternative 5 is also readily implemented, yet more technically difficult than Alternatives 3 and 6. Alternative 5 is more readily implemented than on-site options of Alternative 4 because oxidation and solvent extraction are less technically complex than incineration or thermal desorption. Also, Alternative 5 does not need as extensive a level of bench- and pilot-scale testing as does on-site thermal technologies. As with on-site options of Alternative 4, oxidation and solvent extraction would require a significant amount of space for set-up and operation. The space needed for operation is available at the MTL site. After excavation is completed, pilot tests will be run to determine the most efficient operation of the system while meeting designated clean-up goals.

6.2 COST COMPARISON OF ALTERNATIVES

A present worth cost analysis was performed for each remedial action alternative based on the order of magnitude capital and O&M cost estimates previously presented in Section 5. For this analysis, a 30-year lifetime for alternatives was used. The net present worth was based upon a real interest rate (prime interest rate minus inflation rate) of 3%. A cost summary comparison for the alternatives, including present-worth costs, is also presented in Table 6-2.

A sensitivity analysis was performed on the present-worth costs developed for Alternatives 3 through 6 evaluated in the detailed analysis. In general, a sensitivity analysis can evaluate the effect that variations in specific assumptions associated with the design, implementation, operation, present-worth rate, and design life of that alternative can have on the estimated cost of that alternative. The cost assumptions made are dependent on estimated volumes, work rates, and performance of the remedial technologies, and are subject to various degrees of uncertainty. The sensitivity of the present worth costs to these uncertainties may be evaluated by varying the line item costs and evaluating the range of possible present-worth costs.

The most significant variable is the estimated soil volume for remediation. The vast majority of live items in the cost analysis for Alternatives 3 to 6 are dependent on this volume. A sensitivity analysis was performed around this variable. The soil volume was varied by 70% (-30%) and 150% (+50%) of the baseline soil volume. Present-worth costs for each variation were calculated and are presented in Table 6-3.

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Table 6-2

Cost Comparison Summary of Remedial Action Alternatives

Alternative	Reuse Scenario	Capital Cost ($)	Annual O&M Cost ($) Years 1 to 30	Present Worth Cost ($)
S1 - No Action	All Scenarios	0	1,440	27,400
S2 - Institutional Actions	All Scenarios	12,000	8,500	178,600
S3 - Capping of Soils	Scenario 1	2,637,000	112,000	4,832,000
	Scenario 2	3,259,000	138,000	5,964,000
	Scenario 3	2,637,000	112,000	4,832,000
S4 Option A - Soil Excavation, Treatment Using On-Site Incineration, and On-Site Backfilling	Scenario 1	12,700,000	1,400	12,727,000
	Scenario 2	14,740,000	1,400	14,767,000
	Scenario 3	12,700,000	1,400	12,727,000
S4 Option B - Soil Excavation and Treatment Using Off-Site Incineration	Scenario 1	46,402,000	1,400	46,429,000
	Scenario 2	56,763,000	1,400	56,790,000
	Scenario 3	46,402,000	1,400	46,429,000
S4 Option C - Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling	Scenario 1	16,057,000	1,400	16,084,000
	Scenario 2	19,252,000	1,400	19,279,000
	Scenario 3	16,057,000	1,400	16,084,000
S5 Option A - Soil Excavation, Treatment Using On-Site Chemical Oxidation, and On-Site Backfilling	Scenario 1	5,061,000	1,400	5,088,000
	Scenario 2	6,152,000	1,400	6,179,000
	Scenario 3	5,061,000	1,400	5,088,000
S5 Option B - Soil excavation, Treatment Using On-Site Solvent Extraction, and On-site Backfilling	Scenario 1	10,773,000	1,400	10,800,000
	Scenario 2	13,125,000	1,400	13,152,000
	Scenario 3	10,773,000	1,400	10,800,000
S6 - Soil Excavation and Off-Site Disposal or Reuse	Scenario 1	9,718,000	1,400	9,745,000
	Scenario 2	11,855,000	1,400	11,882,000
	Scenario 3	9,718,000	1,400	9,745,000

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Table 6-3

Cost Sensitivity Analysis of Remedial Action Alternatives

Alternative	Reuse Scenario	Sensitivity Parameter	Present Worth Cost ($)
S3 - Capping of Soils	Scenario 1	-30% Soil Volume	3,571,000
		Baseline Soil Volume	4,832,000
		+50% Soil Volume	6,949,000
	Scenario 2	-30% Soil Volume	4,395,000
		Baseline Soil Volume	5,964,000
		+50% Soil Volume	8,597,000
	Scenario 3	-30% Soil Volume	3,571,000
		Baseline Soil Volume	4,832,000
		+50% Soil Volume	6,949,000
S4 Option A - Soil Excavation, Treatment Using On-Site Incineration, and On-Site Backfilling	Scenario 1	-30% Soil Volume	9,946,000
		Baseline Soil Volume	12,727,000
		+50% Soil Volume	17,361,000
	Scenario 2	-30% Soil Volume	11,379,000
		Baseline Soil Volume	14,767,000
		+50% Soil Volume	20,404,000
	Scenario 3	-30% Soil Volume	9,946,000
		Baseline Soil Volume	12,727,000
		+50% Soil Volume	17,361,000
S4 Option B - Soil Excavation and Treatment Using Off-Site Incineration	Scenario 1	-30% Soil Volume	32,536,000
		Baseline Soil Volume	46,429,000
		+50% Soil Volume	69,583,000
	Scenario 2	-30% Soil Volume	39,793,000
		Baseline Soil Volume	56,790,000
		+50% Soil Volume	85,118,000
	Scenario 3	-30% Soil Volume	32,536,000
		Baseline Soil Volume	46,429,000
		+50% Soil Volume	69,583,000

Table 6-3

Cost Sensitivity Analysis of Remedial Action Alternatives (Continued)

Alternative	Reuse Scenario	Sensitivity Parameter	Present Worth Cost ($)
S4 Option C - Soil Excavation, Treatment Using On-Site Thermal Desorption, and On-Site Backfilling	Scenario 1	-30% Soil Volume	11,758,000
		Baseline Soil Volume	16,084,000
		+50% Soil Volume	23,295,000
	Scenario 2	-30% Soil Volume	13,998,000
		Baseline Soil Volume	19,279,000
		+50% Soil Volume	28,080,000
	Scenario 3	-30% Soil Volume	11,758,000
		Baseline Soil Volume	16,084,000
		+50% Soil Volume	23,295,000
S5 Option A - Soil Excavation, Treatment Using On-Site Chemical Oxidation, and On-Site Backfilling	Scenario 1	-30% Soil Volume	3,603,000
		Baseline Soil Volume	5,088,000
		+50% Soil Volume	7,561,000
	Scenario 2	-30% Soil Volume	4,372,000
		Baseline Soil Volume	6,179,000
		+50% Soil Volume	9,191,000
	Scenario 3	-30% Soil Volume	3,603,000
		Baseline Soil Volume	5,088,000
		+50% Soil Volume	7,561,000
S5 Option B - Soil excavation, Treatment Using On-Site Solvent Extraction, and On-site Backfilling	Scenario 1	-30% Soil Volume	7,635,000
		Baseline Soil Volume	10,800,000
		+50% Soil Volume	16,075,000
	Scenario 2	-30% Soil Volume	9,286,000
		Baseline Soil Volume	13,152,000
		+50% Soil Volume	19,596,000
	Scenario 3	-30% Soil Volume	7,635,000
		Baseline Soil Volume	10,800,000
		+50% Soil Volume	16,075,000

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Table 6-3

Cost Sensitivity Analysis of Remedial Action Alternatives (Continued)

Alternative	Reuse Scenario	Sensitivity Parameter	Present Worth Cost ($)
S6 - Soil Excavation and Off-Site Disposal or Reuse	Scenario 1	-30% Soil Volume	6,856,000
		Baseline Soil Volume	9,745,000
		+50% Soil Volume	14,564,000
	Scenario 2	-30% Soil Volume	8,355,000
		Baseline Soil Volume	11,882,000
		+50% Soil Volume	17,762,000
	Scenario 3	-30% Soil Volume	6,856,000
		Baseline Soil Volume	9,745,000
		+50% Soil Volume	14,564,000

SECTION 7

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Eric Engwell - Chemist (EMP)
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Bob Pasternak - Test Engineer (MRM)
Wai Chen - Chemist (MRM)

Notes:
BRAC = Base Realignment and Closure
COMDR = Commander
D = Director
EMP = Emerging Materials Division
FED = Facilities Engineering Division
MEF = Materials Exploitation Division
MRM = Materials Reliability Division
RK = Risk Management Division